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A Vegetation Analysis of Plant Communities in and Around Selected Holding Ponds at McClintic Wildlife Management Area, Mason County, West Virginia

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by

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ABSTRACT

A Vegetation Analysis of Plant Communities in and Around Selected Holding Ponds at McClintic Wildlife Management Area, Mason County, West Virginia

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Russell Bowman Shrader

This study was conducted as an analysis of vegetation in and around four ponds at McClintic Wildlife Management Area (MWMA), located in Mason County, West Virginia. The MWMA is the former West Virginia Ordnance Works (WVOW), having served as a trinitrotoluene (TNT) manufacturing site from 1941-1946. Such history presents the area with unique conditions resulting in diverse types and amounts of plants, since any type of forest disturbance, regardless of cause, alters ecosystem functions.

This project was originally designed as part of a groundwater pump-and-treat plan for MWMA, where potential impacts of groundwater removal to ponds and the associated plant communities would be assessed over two growing seasons. However, shortly after being initiated, the extraction was terminated. Vegetation studies were continued for the planned time in order to serve as comparative analysis should a similar project be reinitiated. The objectives of this study were:

(1) to characterize plant communities in and around selected holding ponds, through monthly sampling over two consecutive growing seasons;

(2) to compare vegetation among different pond sites;

(3) to assess vegetation changes between sampling years within each pond site; and

(4) to provide baseline data of plant communities for use in future research.

Four plant strata – trees, shrubs, herbaceous, and aquatic vegetation – were sampled; monthly sampling was performed from June-November 1997 and April-October 1998 in plant communities in and around the selected sites for all growth strata except trees, which were sampled once per year. Plants were sampled at each pond site by (1) two 100 m^2 plots for trees; (2) four 25 m^2 plots for shrubs; and (3) six 1 m^2 plots for herbaceous and aquatic vegetation.

For data analysis, importance values were calculated and used to run separate detrended correspondence analysis (DCA) for each growth stratum. One-way analysis of variance (ANOVA) was used for seasonal patterns of dominant herbaceous and aquatic vegetation, and to compare significant differences among mean cover values for aquatic and herbaceous species.

A total of 72 species in 37 families were sampled over the course of the study. Many of the same species occurred in the tree, shrub, and herbaceous communities. Most species found at a pond site during one year were present the other year, though some changes in species occurred in all strata. DCA showed that while some changes in importance of species occurred between 1997 and 1998, such changes were not substantial. Species in the shrub stratum showed the smallest amount of variability between years. Aquatic species showed more noticeable differences between pond sites, possibly due to differences in pond water levels or nutrient content.

Pond 4 had some species not found at other pond sites, presumably due to swampy conditions of that area. These included *Sphagnum* sp., *Ilex montana* T. & C., *Rhus vernix* L., and *Osmunda cinnamomea* L.

The top two species in each stratum (for all pond sites) were as follows: *Acer rubrum* L. and *Nyssa sylvatica* Marsh. for trees; *Elaeagnus umbellata* Thunb. and *Carya ovata* (Mill.) K. Koche for shrubs; *Lonicera japonica* Thunb. and *Panicum* sp. for herbs; and *Ceratophyllum demersum* L. and *Lemna minor* L. for aquatic vegetation. Distribution of these species varied among pond sites.

More than 60% of plant species in all growth strata had defined wetland status. Sixty-seven percent (67%) of shrubs and herbs, 80% of trees, and 91% of aquatic species were classified as facultative, facultative upland, facultative wetland, or obligate wetland species.

Without previous vegetation documentation, it is difficult to assess the extent that establishment of WVOW had on plant species composition at MWMA. However, it is possible that many species currently present at the site were present prior to establishment of the manufacturing plant. Future research should be performed, using results from this thesis as baseline data, because a two-year sampling period of the area is not enough to draw definitive conclusions about MWMA.

ACKNOWLEGEMENTS

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I want to give special thanks to my advisor, Dr. Jeffrey May. Dr. May was the first professor I knew at Marshall, and his attitude quickly made me realize I had made the right decision by coming to Marshall University. Also, I have gained an incredible amount of knowledge about Microsoft Word and Excel from him, and he helped to show me that those programs are not (always) the enemy.

Dr. Frank Gilliam was of invaluable help, guidance, and support throughout the course of my graduate study. His plant ecology course showed me the "ins and outs" of scientific research and the good and the bad. Dr. G. also was of enormous help in data analyses and always showed a caring, positive attitude. Even when I "goofed up" my analyses, he always was willing to help me again. I can now say that I can use Lotus, Compose, and Canoco successfully, at least sometimes. I feel fortunate to have known and had the opportunity to work with such a knowledgeable ecologist.

I cannot even begin to express the invaluable assistance that Dr. Dan Evans provided in plant identification; his knowledge of plants absolutely amazes me. He would either instantly or within about a minute of examination know to the species level any unknown specimen I would show him. Dr. Evans's classes in plant taxonomy, economic botany, and wetlands provided me with invaluable knowledge for which I always will be grateful. Dr. Evans's care and concern for students is unmatched. I knew from the first trip I took with him to McClintic that I was in the company of a great professor.

I must also thank Drs. Donald Tarter and Margaret Bird. To Dr. Tarter, thank you for introducing me to the subjects of limnology and animal ecology. Though my knowledge of benthics and fish are still limited, I gained incredible knowledge from his classes about subjects to which I had little previous exposure. Dr. Bird, thank you for lending a helping hand and listening ear to whatever questions or problems I encountered.

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The McClintic trips would not have been possible without the help, support, and companionship of Anne Hubbard and Mark Wheeler. While we got very disgusted climbing through and over endless stems (especially multifloral rose!), I always will value the times we spent there sampling plants and fighting off flies and ticks.

I know that coming to Marshall for a master's degree was the best choice for me. These have been the best two years of my life. Thanks to everyone!

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Chapter I. Introduction

This thesis is presented as a study of dominant vascular plant life in and around selected holding ponds at McClintic Wildlife Management Area (MWMA), located in Mason County, West Virginia. The MWMA is the former West Virginia Ordnance Works (WVOW), a World War II trinitrotoluene (TNT) manufacturing site. Due to such history, the area presents unique conditions that result in diverse types and amounts of plants. Any type of forest disturbance, either by natural or human factors, alters ecosystem functions that regulate element cycling and retention, including element uptake, evapotranspiration, decomposition, and nitrogen transformations (Boring et al. 1981, Witkamp 1971, Likens et al. 1978); therefore, establishment of WVOW may have resulted in ecosystem changes.

"Community" is a general term that can be used in a variety of ways to describe any size or type of vegetation (Barbour et al. 1999). Community and vegetation studies have been conducted for many years to determine relationships among dominant plant species and to examine similarities and differences between communities. Such studies can be performed to analyze overstory, understory, herbaceous, and aquatic plant species. In addition to being used for floristic studies, analyses of plant communities often are used for indication of environmental impact (Gauch 1982).

This project originally was begun as part of a groundwater extraction pump-and-treat plan for MWMA, developed by the Unites States Army Corps of Engineers (May et al. 1999). The proposed extraction called for monitoring potential impacts of groundwater removal to ponds and the nearby plant communities. However, the groundwater extraction was terminated in July 1997, shortly after its initiation. Despite the fact that the study was not utilized as initially intended, it can be used for comparative analysis should a similar project be reinitiated by a federal or private agency. Previous vegetation studies of the area are lacking, so such data may be useful as baseline data in the future.

This project aimed to document baseline data for a representative portion of the entire area rather than be exhaustive research describing all vascular plants present. Because of the lack of previous vegetation studies, consideration of all plant types (trees, shrubs, herbaceous vegetation, aquatic vegetation) was necessary to provide data for characterization and analysis of plant communities. The objectives of the present study were:

(1) to characterize plant communities in and around selected holding ponds at MWMA, through monthly sampling over two consecutive growing seasons;

(2) to compare vegetation among different pond sites;

(3) to assess vegetation changes, within each pond site, between sampling years; and

(4) to provide baseline data of plant communities for use in future research.

Chapter II. Materials and Methods

Site History

The McClintic Wildlife Management Area, in Camp Conley, Mason County, West Virginia, occupies about one third of the former West Virginia Ordnance Works, which produced TNT from 1941 until 1946. Camp Conley is located along the Ohio River, approximately 8 km north of Point Pleasant, West Virginia, on State Route 62.

The site contained ten TNT manufacturing areas, two acid producing areas, a sellite plant, toluene storage magazine, acid loading areas on the Ohio River, 100 storage magazines, wastewater holding ponds, burning grounds, administrative area, and employee housing. Prior to establishment of the site, major land uses were for crops (approximately 50% of the area), forest, pasture, and approximately 30 farm residences. Factors prompting use of this area for manufacturing included proximity to TNT consuming industrial plants, suitable terrain, proximity to adequate transportation routes and methods, and proximity to raw materials (U.S. Army Corps of Engineers 1993).

During the TNT manufacturing process, liquid wastes were produced. Many of these wastes eventually were discharged or drained into the Ohio River. Surface and subsurface soils and groundwater in areas of MWMA are still contaminated with nitroaromatic residues. In addition, a potential exists for contamination of other areas due to post-operation contaminant migration. At the close of operations in 1946, an effort was made to decontaminate WVOW. No records currently exist regarding the general extent of decontamination, but it was theorized that 100 percent decontamination could not be attained. The industrial portion of the site was deeded to the State of West Virginia, with the stipulation that the site be used for wildlife management. Approximately one-third of the area is now occupied by MWMA, and it is operated by the West Virginia Department of Natural Resources (DNR).

In May 1981, ranger officials observed seepage of wastewater adjacent to retention Pond 13. The West Virginia DNR and the U.S. Environmental Protection Agency (EPA) investigated this incident. The shallow ground water discharging to pond 13 was found to be contaminated by 2,4-dinitrotoluene (2,4-DNT, up to 7,100 μg/L), 2,6-dinitrotoluene (2,6-DNT, 1,300 μg/L), 2,4,6-trinitrotoluene (TNT, 166 μg/L in one sample), and phenol (31 μg/L), all hazardous substances pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (U.S. Army Corps of Engineers 1993).

Study Area

The MWMA is located in the eastern deciduous forest of North America (Greller 1988). This type of forest is characterized as having a mature, closed forest canopy reaching 30 m. The central region of the deciduous forest contains subcanopy, shrub layers, and distinct herb layers. West Virginia is a state predominately covered by deciduous forest (Greller 1988), and western West Virginia contains, in the most mesic areas, oaks and deciduous dicot species such as *Quercus alba* L., *Carya ovata* (Mill.) K. Koche, *Nyssa sylvatica* Marsh, *Prunus serotina* Ehrh., and *Acer rubrum* L. (Greller 1988), species which occur at the site. Many species in West Virginia are characterized by the Appalachian floristic element, including such species as *Q. alba*, *Cornus florida* L., *Corylus americana* Walt., and *Sambucus canadensis* L. (Core 1966), all characteristic species of MWMA.

The climate of Mason County is warm and temperate, and precipitation is well distributed throughout the year. Less than 50 centimeters of snowfall occur each year, and what snow is present does not remain on the ground for long periods of time, providing little ground cover or protection. Records at Point Pleasant indicate that the average growing season is 176 days (U.S.D.A. 1961). Summer months (June, July, and August) have the highest average monthly precipitation (U.S.D.A. 1961). Figure 1 illustrates average monthly precipitation records for Point Pleasant from 1890 to 1953 (adapted from U.S.D.A. 1961). July is the hottest month, with summer months (June, July, and August) having highest average annual temperatures. Monthly minimum and maximum temperatures are graphed in Figure 2. Lakin loamy fine sand soil and Wheeling silt loam soil have been found in and around MWMA (U.S.D.A. 1961), although it cannot definitively be concluded that these soil types are the only ones present at MWMA (or the dominant types).

Field Sampling

For convenience, throughout this thesis, I will designate each pond site by the respective pond number; e.g., "Pond 4" refers to the sampled area in and adjacent to Pond 4. Vegetation in and around three holding ponds in potential cones of depression

Figure 1. Average monthly precipitation at Point Pleasant, West Virginia, from 1890-1953 (Adapted from U.S.D.A. 1961).

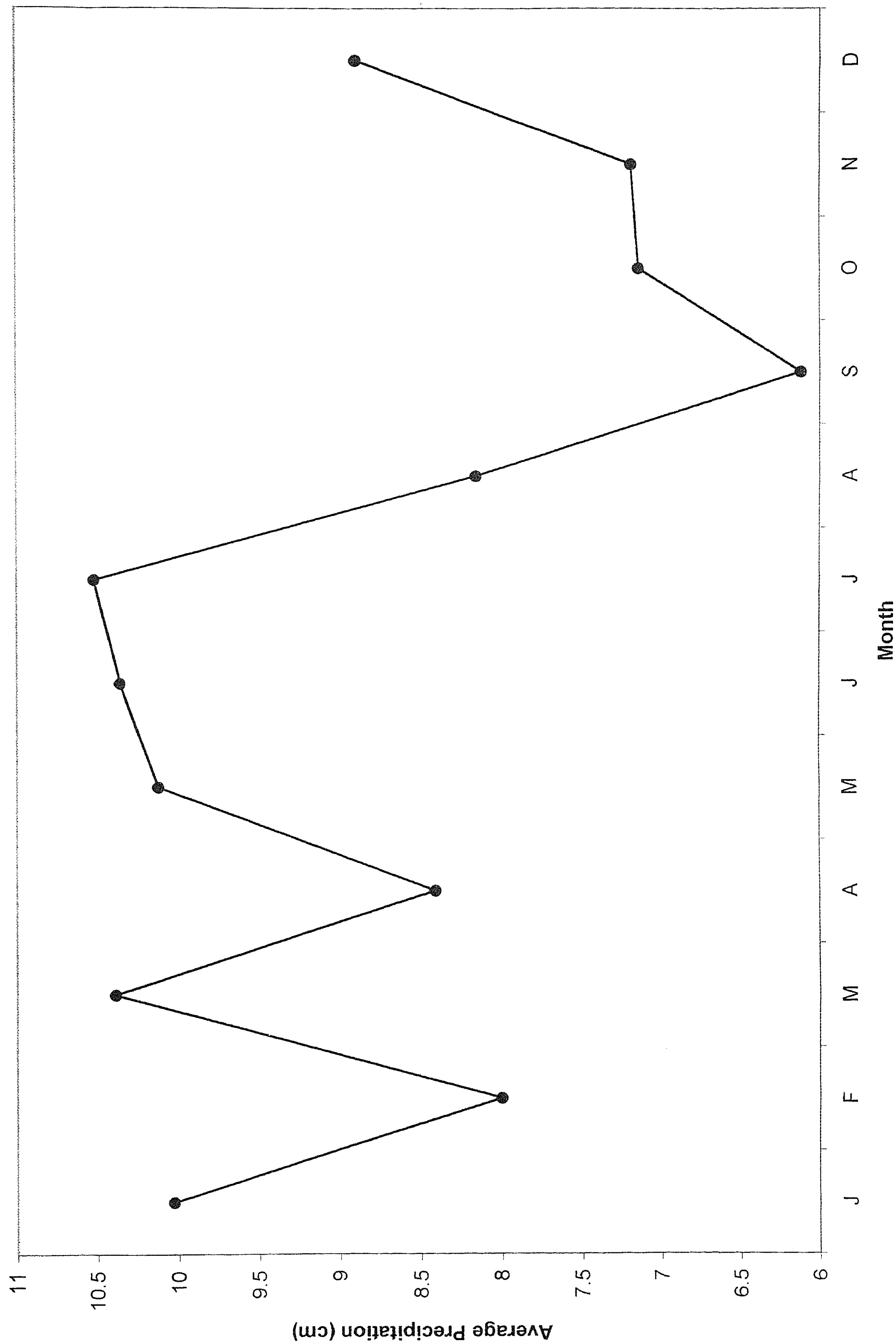
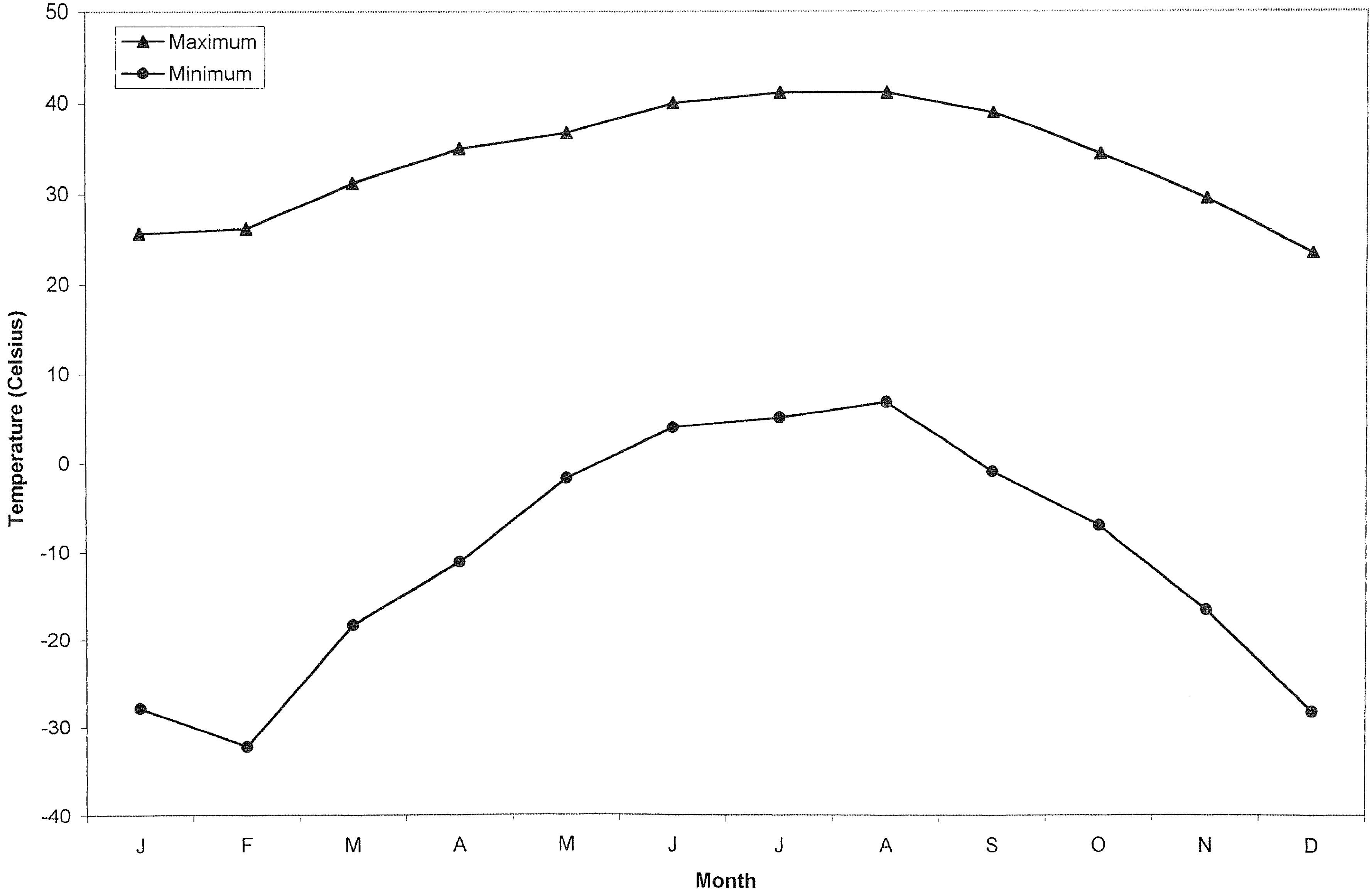
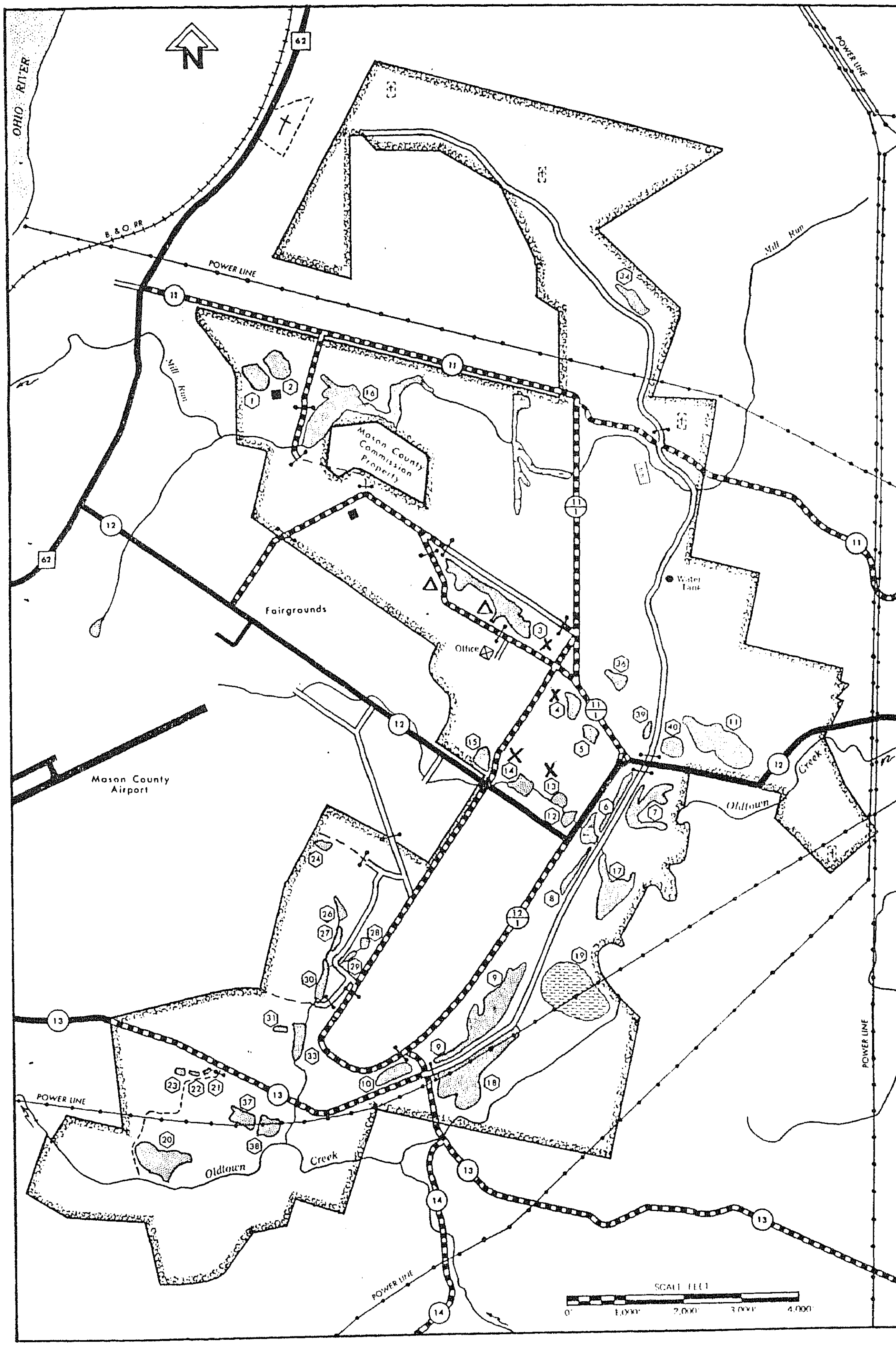

Average Precipitation (cm)
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
J
F
M
A
M
J
J
A
S
O
N
D
Month

Figure 2. Monthly absolute minimum and maximum temperatures at Point Pleasant, West Virginia, from 1894-1953 (Adapted from U.S.D.A. 1961).



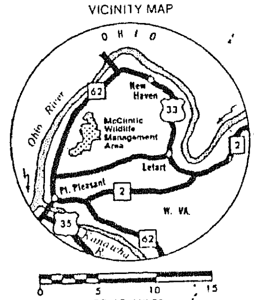
Maximum
Minimum
50
40
30
20
10
0
-10
-20
-30
-40
Temperature (Celsius)
J
F
M
A
M
J
J
A
S
O
N
D
Month

Figure 3. Overall map of McClintic Wildlife Management Area, Mason County, West Virginia.



AREA BOUNDARY
PAVED ROAD
IMPROVED ROAD
UNIMPROVED ROAD
TRAIL
POWER LINE
RAILROAD
OFFICE
BUILDING
CAMPING AREA
GATE
STREAM
POND, numbered
FLOODED TIMBER
MARSH
CEMETERY
RIFLE RANGE

VICINITY MAP



McCLINTIC
WILDLIFE MANAGEMENT AREA

MAILING ADDRESS: Rt. 1, Box 484
Pt. Pleasant, WV 25550

TELEPHONE: 304-675-4380

(locations likely to be impacted by the planned pump-and-treat process) were selected for observation and sampling (Figure 3; Ponds 3, 13, and 14). Pond 4, located outside the treatment area, was chosen as a control pond in order to distinguish effects of water withdrawal from those of climate, such as drought conditions. Ponds varied in shape, depth, extent of watershed, underlying soils, disturbance, and rate at which water was lost.

Sampling was conducted in plant communities in and around Ponds 3, 4, 13, and 14. Four plant strata were sampled: trees, shrubs, herbaceous, and aquatic vegetation. At every pond site, two permanent rectangular transects, each 20 m x 10 m, were established; these transects were perpendicular to the margin of the pond Within each transect, two 100 m^2 plots were established for assessment of trees. Four subplots in all transects, each 25 m^2, were created for assessing shrubs. Portable 1 m^2 plots were made from plastic tubing and were used to create six plots for analysis of the herbaceous layer along each transect line. According to Gauch (1982), 1 m^2 areas for herbs are commonly employed in American studies. Aquatic shrubs and herbs, including emergent and submerged plant species, were quantified within six 1 m^2 plots in the water. Because plant distributions involve a variety of spatial scales, any plot size may be appropriate for certain species but either too large or too small for other species; as a result, having a larger number of smaller samples provides more accurate descriptions of plant communities (Gauch 1982).

Wherever possible, plant species were identified to the species level. Table 1 gives four-letter code names (first two letters of genus and species names) used for all

Table 1. Species encountered in all growth strata at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. Given are four-letter species codes, scientific names with authorities (where possible), and family names. Nomenclature follows Strausbaugh and Core (1977).

Code	Scientific Name	Family
ACRU	*Acer rubrum* L.	Aceraceae
AEGL	*Aesculus glabra* Willd.	Hippocastanaceae
ALSE	*Alnus serrulata* (Ait.) Willd.	Corylaceae
ASPL	*Asplenium platyneuron* (L.) Oakes	Polypodiaceae
ASTR	*Asimina triloba* (L.) Dunal.	Annonaceae
ATPY	*Athyrium pycnocarpon* (Spreng.) Tidestr.	Polypodiaceae
BISP	*Bidens* sp.	Asteraceae
CAFR	*Carex frankii* Kunth	Cyperaceae
CAOV	*Carya ovata* (Mill.) K. Koche	Juglandaceae
CASP	*Carex* sp.	Cyperaceae
CEDE	*Ceratophyllum demersum* L.	Ceratophyllaceae
CEOC	*Cephalanthus occidentalis* L.	Rubiaceae
CHMA	*Chimaphilla maculata* (L.) Pursh.	Clethraceae
COAM	*Corylus americana* Walt.	Corylaceae
COFL	*Cornus florida* L.	Cornaceae
CUOR	*Cunila origanoides* (L.) Britton	Lamiaceae
CYSP	*Cyperus* sp.	Cyperaceae
DASP	*Danthonia spicata* (L.) Beauv.	Poaceae
DILO	*Diervilla lonicera* Mill.	Caprifoliaceae
ELUM	*Elaeagnus umbellata* Thunb.	Elaeagnaceae
EUPE	*Eupatorium perfoliatum* L.	Asteraceae
EUSE	*Eupatorium serotinum* Michx.	Asteraceae
EUSP	*Eupatorium* sp.	Asteraceae
FAGR	*Fagus grandifolia* Ehrh.	Fagaceae
HYVI	*Hypericum virginicum* L.	Hypericaceae
ILMO	*Ilex montana* T. & C.	Aquifoliaceae
JUEF	*Juncus effusus* L.	Juncaceae
LEMI	*Lemna minor* L.	Lemnaceae
LEOR	*Leersia oryzoides* (L.) Sw.	Poaceae
LIBE	*Lindera benzoin* (L.) Blume	Lauraceae
LOJA	*Lonicera japonica* Thunb.	Caprifoliaceae
LUPA	*Ludwigia palustris* (L.) Ell.	Onagraceae
LYAM	*Lycopus americanus* Muhl.	Lamiaceae
LYFL	*Lycopodium flabelliforme* Blanchard	Lycopodiaceae
LYVI	*Lycopus virginicus* L.	Lamiaceae
MOAL	*Morus alba* L.	Moraceae

Table 1 Continued

Code	Scientific Name	Family
NYSY	*Nyssa sylvatica* Marsh.	Nyssaceae
ONSE	*Onoclea sensibilis* L.	Polypodiaceae
OSCI	*Osmunda cinnamomea* L.	Osmundaceae
PAQU	*Parthenocissus quinquefolia* (L.) Planch	Vitaceae
PASP	*Panicum* sp.	Poaceae
PHAM	*Phytolacca americana* L.	Phytolaccaceae
PLOC	*Platanus occidentalis* L.	Platanaceae
POAC	*Polystichum acrostichoides* (Michx.) Schott	Polypodiaceae
POHY	*Polygonum hydropiperoides* Michx.	Polygonaceae
POPE	*Polygonum persicaria* L.	Polygonaceae
POSA	*Polygonum sagittatum* L.	Polygonaceae
POSI	*Potentilla simplex* Michx.	Rosaceae
PRSE	*Prunus serotina* Ehrh.	Rosaceae
QUAL	*Quercus alba* L.	Fagaceae
QUIM	*Quercus imbricaria* Michx.	Fagaceae
QUPA	*Quercus palustris* Muenchh.	Fagaceae
QUVE	*Quercus velutina* Lam.	Fagaceae
RHRA	*Rhus radicans* L.	Anacardiaceae
RHVE	*Rhus vernix* L.	Anacardiaceae
ROMU	*Rosa multiflora* Thunb.	Rosaceae
ROPS	*Robinia pseudo-acacia* L.	Fabaceae
RUHI	*Rubus hispidus* L.	Rosaceae
RUSP	*Rubus* sp.	Rosaceae
SAAL	*Sassafras albidum* (Nutt.) Nees	Lauraceae
SACA	*Sambucus canadensis* L.	Caprifoliaceae
SCSP	*Scirpus* sp.	Cyperaceae
SEFA	*Setaria faberii* Herrm.	Poaceae
SMGL	*Smilax glauca* Walt.	Liliaeae
SOSP	*Solidago* sp.	Asteraceae
SPSP	*Sphagnum* sp.	Sphagnaceae
SPTO	*Spiraea tomentosa* L.	Rosaceae
UTGI	*Utrichularia gibba* L.	Lentibulariaceae
VIPA	*Viola papilionacea* Pursh	Violaceae
VIPR	*Viburnum prunifolium* L.	Caprifoliaceae
VIRE	*Viburnum recognitum* Fernald	Caprifoliaceae
VISP	*Vitis* sp.	Vitaceae

species throughout this thesis, together with family, genus and species names, and authorities. Nomenclature followed Strausbaugh and Core (1977). Authorities are not given for plants that were identifiable only to genus level. A total of 72 species in 37 families were encountered over the two-year study. Representatives of unknown plants were collected for identification and comparison with those in the Marshall University Herbarium. Trees, defined as live woody plants equal to or greater than 2.5 cm DBH (diameter at breast height) were measured at each pond once per year. Basal area for each stem was calculated from DBH measurements and used in determining relative importance values within the community. All other quantitative measurements were made monthly, from June-November 1997 and April-October 1998. Average height (m) and density (stems/ha) were used to determine relative importance values (IV) for shrubs (woody plants greater than 1.0 m in height, but too small to be categorized as trees) in the understory. Percent cover was used to quantify herbaceous (plants less than 1.0 m in height) and aquatic vegetation. Percent cover measurements were estimated to the nearest percent. Due to the length of this study and the number of samples taken, minor differences or errors in data collection were expected to have little impact on overall results, which is supported by Gauch (1982).

Data Analysis

Importance values were calculated as the average of relative basal area and relative density for trees; as the average of relative height and relative density for shrubs; and as relative cover for herbaceous and aquatic species. One-way analysis of variance

(ANOVA) was used to demonstrate seasonal patterns of dominant herbaceous and aquatic species and to compare significant differences among mean cover values for aquatic and herbaceous species.

Detrended correspondence analysis (DCA), a common ordination technique, was used for analysis of community data. Ordination describes arrangement of vegetation samples in relation to each other based on similarities of species composition (Barbour et al. 1999). Ordination is a type of multivariate analysis, a branch of mathematics that treats numerous variables simultaneously; multivariate analyses summarize data and reveal their structure (Gauch 1982). Because community sites are characterized by abundance of a variety of species, community data are multivariate. There are two main roles of multivariate analysis in community ecology, which are (1) to discover structure in data and (2) to provide an objective, easy summarization of data. In ordination, sample and species relationships are represented with similar entities close to each other and dissimilar entities far apart (Gauch 1982).

Although there are several ordination techniques designed to analyze community data, DCA is beneficial because this technique ensures that differences in ordination space indicate comparable floristic or ecological differences between stands (Barbour et al. 1999). DCA ordinations also allow for direct assessment of species diversity and gradient lengths among ponds (Gilliam et al. 1995). Calculated importance values were used to run separate DCA analyses for each stratum.

Chapter III. Results and Discussion

Tree Stratum

Acer rubrum, *Nyssa sylvatica*, and *Quercus imbricaria* had substantially higher importance values than any other species and thus may be considered the dominant tree species over the study area (Table 2). According to Braun (1950), tree species such as *Quercus* and *Acer* are characteristic of deciduous forests. Conversely, some species, such as *Quercus alba* and *Elaeagnus umbellata*, were of minimal significance to overall importance of the tree stratum.

Pond 3 showed notable change in trees between 1997 and 1998 (Table 3). *Asimina triloba*, present as a tree species in 1997, was not found in 1998. *Quercus imbricaria* and *Cornus florida* were present as trees in 1998 but not in 1997. *Nyssa sylvatica* and *Quercus palustris* decreased in importance from 1997 to 1998. Overall total basal area and density at Pond 3 increased from 1997 to 1998 (11.64 m^2/ha for basal area, 225 stems/ha for density).

Pond 4 had five tree species in 1997 and six species in 1998, due to the addition of *Elaeagnus umbellata* (Table 4). *Fagus grandifolia* had higher total basal area and density in 1998, while *Nyssa sylvatica* had higher total basal area in 1998. *Cornus florida* and *Asimina triloba* had lower densities in 1998 than 1997, most likely the result of stem mortality. As a result, both total basal area and density were lower for Pond 4 in 1998 than in 1997.

Table 2. Basal area (BA, m/ha), relative basal area (R BA), density (DEN, stems/ha), relative density (RD), and importance value (IV) of trees at all ponds for 1997 and 1998 at McClintic Wildlife Management Area, Mason County, West Virginia. The importance values were calculated as the average of relative basal area and relative density.

Species	BA	R BA	DEN	RD	IV
Acer rubrum	8.93	44.85	253.13	31.76	38.31
Nyssa sylvatica	2.58	12.96	243.75	30.59	21.77
Quercus imbricaria	5.87	29.48	68.75	8.63	19.05
Cornus florida	0.42	2.11	71.88	9.02	5.56
Quercus palustris	0.99	4.97	18.75	2.35	3.66
Asimina triloba	0.25	1.26	46.88	5.88	3.57
Fagus grandifolia	0.17	0.85	40.63	5.10	2.98
Sassafras albidum	0.01	0.05	37.50	4.71	2.38
Quercus alba	0.68	3.42	6.25	0.78	2.10
Elaeagnus umbellata	0.01	0.05	9.38	1.18	0.61
Totals	19.91	100.00	796.90	100.00	100.00

Table 3. Basal area (BA, m/ha), relative basal area (R BA), density (DEN, stems/ha), relative density (RD), and importance value (IV) for Pond 3 at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. The importance values were calculated as the average of relative basal area and relative density.

1997 Species	BA	R BA	DEN	RD	IV
Acer rubrum	8.91	65.75	300	54.55	60.15
Asimina triloba	1.33	9.82	150	27.27	18.55
Quercus palustris	2.65	19.53	25	4.55	12.04
Nyssa sylvatica	0.67	4.91	75	13.64	9.25
Totals	13.56	100.00	550	100.00	100.00

1998 Species	BA	R BA	DEN	RD	IV
Acer rubrum	17.86	70.91	450	58.06	64.49
Cornus florida	2.53	10.03	225	29.03	19.53
Nyssa sylvatica	2.97	11.79	25	3.23	7.51
Quercus imbricaria	1.75	6.93	25	3.23	5.08
Quercus palustris	0.09	0.34	50	6.45	3.39
Totals	25.20	100.00	775	100.00	100.00

Table 4. Basal area (BA, m/ha), relative basal area (R BA), density (DEN, stems/ha), relative density (RD), and importance value (IV) for Pond 4 at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. The importance values were calculated as the average of relative basal area and relative density.

1997

Species	BA	R BA	DEN	RD	IV
Acer rubrum	12.83	67.26	400	34.04	50.65
Nyssa sylvatica	4.95	25.93	275	23.40	24.67
Cornus florida	0.74	3.87	300	25.53	14.70
Asimina triloba	0.35	1.85	125	10.63	6.24
Fagus grandifolia	0.21	1.09	75	6.38	3.74
Totals	19.08	100.00	1175	100.00	100.00

1998

Species	BA	R BA	DEN	RD	IV
Acer rubrum	10.95	60.91	275	26.19	43.55
Nyssa sylvatica	5.44	30.25	200	28.57	29.41
Fagus grandifolia	1.11	6.15	250	23.81	14.98
Asimina triloba	0.33	1.84	100	9.52	5.68
Elaeagnus umbellata	0.09	0.52	75	7.14	3.83
Cornus florida	0.06	0.33	50	4.76	2.55
Totals	17.98	100.00	1050	100.00	100.00

Table 5. Basal area (BA, m/ha), relative basal area (R BA), density (DEN, stems/ha), relative density (RD), and importance value (IV) for Pond 13 at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. The importance values were calculated as the average of relative basal area and relative density.

1997 Species	BA	R BA	DEN	RD	IV
Quercus imbricaria	15.15	80.99	125	62.50	71.75
Acer rubrum	0.97	5.19	50	25.00	15.09
Quercus alba	2.59	13.82	25	12.50	13.16
Totals	18.71	100.00	200	100.00	100.00

1998 Species	BA	R BA	DEN	RD	IV
Quercus imbricaria	15.41	80.00	125	62.50	71.25
Acer rubrum	0.97	5.04	50	25.00	15.02
Quercus alba	2.88	14.95	25	12.50	13.73
Totals	19.26	100.00	200	100.00	100.00

Table 6. Basal area (BA, m/ha), relative basal area (R BA), density (DEN, stems/ha), relative density (RD), and importance value (IV) for Pond 14 at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. The importance values were calculated as the average of relative basal area and relative density.

1997

Species	BA	R BA	DEN	RD	IV
Acer rubrum	11.59	59.47	300	25.53	42.50
Nyssa sylvatica	0.65	3.33	700	59.57	31.45
Quercus imbricaria	6.51	33.40	125	10.64	22.02
Quercus palustris	0.72	3.69	25	2.13	2.91
Sassafras albidum	0.02	0.10	25	2.13	1.11
Totals	19.49	100.00	1175	100.00	100.00

1998

Species	BA	R BA	DEN	RD	IV
Nyssa sylvatica	5.99	22.98	675	50.00	36.49
Acer rubrum	7.34	28.20	200	14.81	21.51
Quercus imbricaria	8.17	31.36	150	11.11	21.23
Quercus palustris	4.46	17.14	50	3.70	10.42
Sassafras albidum	0.09	0.33	275	20.37	10.35
Totals	26.05	100.00	1350	100.00	100.00

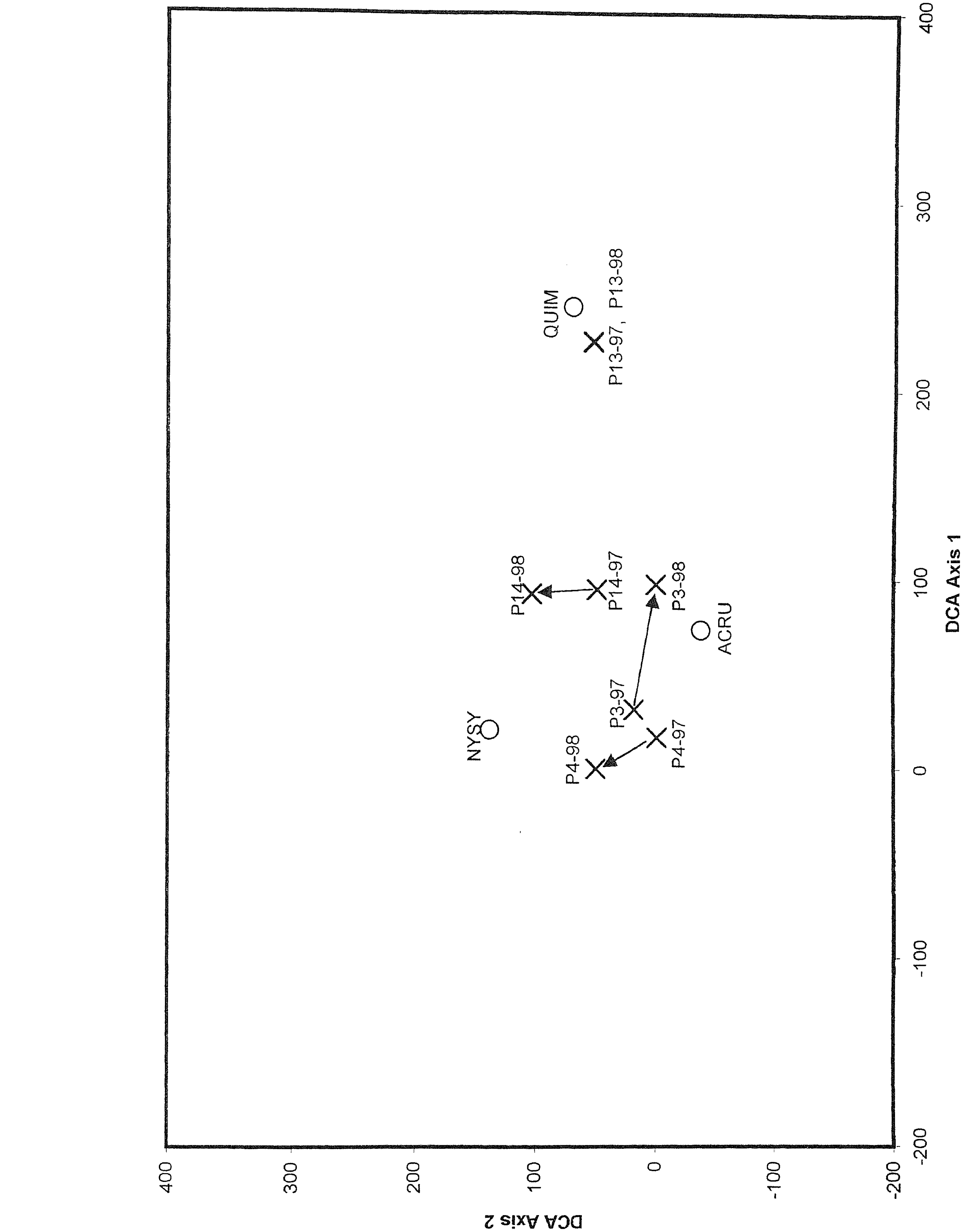
Pond 13 showed minimal change between 1997 and 1998 (Table 5). For both years, the same three species (*Acer rubrum*, *Q. imbricaria*, and *Q. alba*) were present, with very similar importance values. Total basal area increased slightly in 1998 (change of 0.55 m^2/ha), density remained the same (200 stems/ha), and importance values varied by less than one whole number.

The same five tree species present at Pond 14 during 1997 remained at the pond in 1998 (Table 6). Total basal area increased from 1997 to 1998 (approximately 6.5 m^2/ha) and an increase in density also occurred (change of 175 stems/ha). Importance values of *Nyssa sylvatica*, *Quercus palustris*, and *Sassafras albidum* increased from 1997 to 1998, while importance of *Acer rubrum* and *Quercus imbricaria* decreased. *Acer rubrum* was the dominant tree in 1997, while *Nyssa sylvatica* was dominant in 1998.

DCA of the tree stratum for 1997 and 1998 by pond site location showed that overall changes between years were notable but not severe (Figure 4). Pond 13 showed the least change, with nearly identical axes values for both years, supported by negligible change in species present and species importance (Table 5).

Plotted with DCA values for pond sites are the three most dominant tree species: *Acer rubrum*, *Nyssa sylvatica*, and *Quercus imbricaria* (Figure 4). *Acer rubrum* was of greatest importance at Pond 3 and had a higher importance value in 1998 (Table 3), illustrated by the ordination point. While *A. rubrum* was present at each pond, it was of least importance at Pond 13 (Table 5), further evidenced by ordination furthest from Pond 13. *Nyssa sylvatica* was found with greatest importance at Ponds 4 and 14, and was of higher importance in 1998 than 1997 (Tables 4 and 6, respectively), explaining ordination closest to 1998 values for the two ponds. *Quercus imbricaria* was not present at Pond 4

Figure 4. Detrended correspondence analysis (DCA) of tree communities sampled in 1997 and 1998 at McClintic Wildlife Management Area, Mason County, West Virginia, by pond site, with dominant species. Code names for dominant species: NYSY = *Nyssa sylvatica*; ACRU = *Acer rubrum*; QUIM = *Quercus imbricaria*.



DCA Axis 1
DCA Axis 2
-200
-100
0
100
200
300
400
QUIM
P13-97 , P13-98
P14-98
P14-97
P3-98
ACRU
P3-97
NYSY
P4-98
P4-97

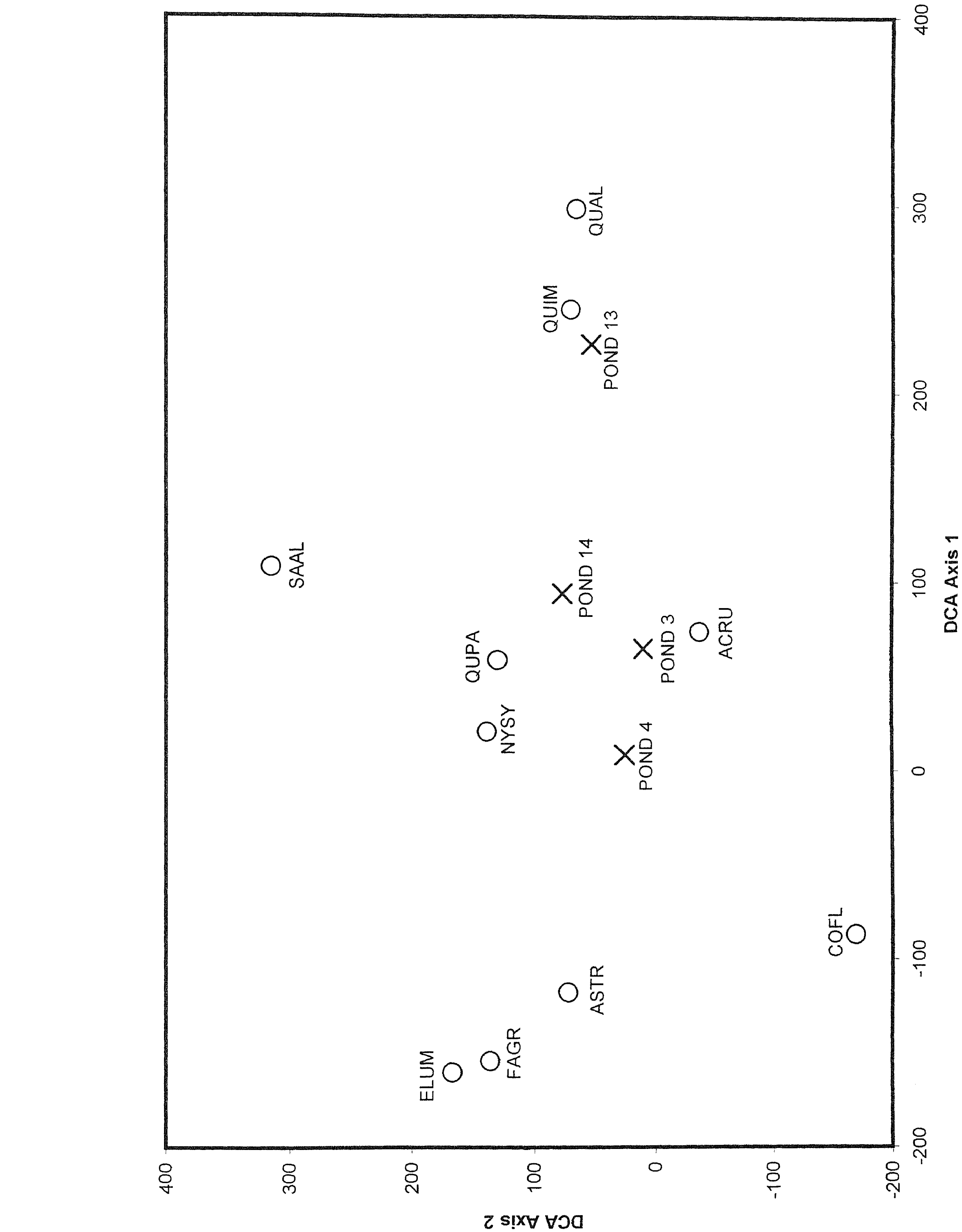
(Table 4) during either year and was of greatest importance at Pond 13 (Table 5), where the tree was the dominant species.

DCA of all tree species with average pond site ordinations showed patterns of similarities and differences among pond sites and species (Figure 5). *Elaeagnus umbellata* and *Fagus grandifolia* were only present at Pond 4 (Table 4) and only in or with highest importance in 1998, illustrated by ordination points closest to Pond 4 and further removed from all other pond sites. *Cornus florida* was present at Ponds 3 and 4 (Tables 3 and 4), with highest importance on Pond 4 during 1997. *Asimina triloba* was present at Pond 4 both years (Table 4) and present on Pond 3 in 1997 (Table 3). The highest importance value was at Pond 3 in 1997 (Table 3). *Nyssa sylvatica*, present at all ponds but Pond 13, was of highest importance at Pond 4 and had higher importance in 1998 than 1997 (Table 4). *Sassafras albidum*, present only at Pond 14, had higher importance in 1998 (Table 6), supported by ordination most closely associated with the pond. *Acer rubrum*, present at all pond sites, had highest importance at Pond 3 in 1998 (Table 3). *Quercus palustris*, present only at Ponds 3 and 14, had highest importance at Pond 3 in 1997 (Table 3). *Quercus imbricaria* was of greatest importance at Pond 13 (Table 5), with nearly identical importance values for both years. *Quercus alba* was only present at Pond 13, with nearly identical importance values for both years (Table 5). Absence of *Q. alba* from all ponds except 13 is illustrated by species ordination in an extreme end of the graph, away from all other ponds and species.

Results of DCA for the tree community suggest that more than one factor helped to ordinate ponds and species in their respective locations on the graphs. First, pond ordinations were determined by species presence. Similarities and differences in species

Figure 5. Detrended correspondence analysis (DCA) of tree species at McClintic Wildlife Management Area, Mason County, West Virginia, Mason County, West Virginia, with ordinations of all species, together with average pond site ordinations for 1997 and 1998. See Table 1 for species code names.

for


DCA Axis 1
DCA Axis 2
-200
-100
0
100
200
300
400
ELUM
FAGR
ASTR
COFL
NYSY
POND 4
QUPA
POND 3
ACRU
POND 14
SAAL
POND 13
QUIM
QUAL

presence and their overall importance values served as factors determining separation of ponds sites. Additionally, site characteristics and conditions (such as site history, soil chemistry, soil moisture) may have had direct effects on distribution of species presence.

Loss of species between 1997 and 1998 may be explained either by species mortality or by sampling inconsistencies between years. For example, *Asimina triloba* was recorded as a tree species on Pond 3 in 1997 but not 1998 (Table 3), as was *Cornus florida*, recorded as a tree on Pond 14 in 1997 but not 1998 (Table 6). Because total basal areas of such species are low compared with other species, it is possible that a sampling error may have resulted in such species being recorded as shrubs in 1998 while they were considered trees in 1997. Such inconsistencies also may apply to small changes in importance values for all species.

Shrub Stratum

In disturbed areas, subdominant trees and herbaceous vegetation can be better indicators of forest type than the trees present (Braun 1950). The mixed mesophytic forest region, including West Virginia, contains a variety of subcanopy trees and shrubs that seldom or never attain canopy position, including *Cornus florida*, *Ilex* sp., *Lindera benzoin*, and *Asimina triloba* (Braun 1950).

Average height, relative height, density, relative density, and importance values for all shrub layer species at each of the sampled ponds over the two-year project are provided in order of decreasing importance values (Table 7). Of all shrub species, *Elaeagnus umbellata*, *Carya ovata*, *Lindera benzoin*, and *Asimina triloba* were most dominant.

Changes in density were observed at all pond sites between 1997 and 1998. Pond 3 had the smallest density change from 1997 to 1998 (approximately 438 stems/ha) while Pond 4 had the highest increase in density (approximately 1682 stems/ha) (Tables 8 and 9, respectively). Pond 14 had the highest density of all ponds in 1997 (Table 11), while Pond 4 had the highest density in 1998 (Table 9). Pond 3 had the lowest density for both years (Table 8). Ponds 4, 13, and 14 had the highest species diversity (each with 16 species), while Pond 3, with 12 species, had slightly lower species diversity.

Pond 4 had several shrub species unique to that site, including *Osmunda cinnamomea*, *Rhus vernix*, and *Ilex montana*. All three species are found in moist areas or in bogs and swamps (Strausbaugh and Core 1977). This is consistent with the location

Table 7. Average height (AH, m), Relative Height (RH), Density (DEN, stems/ha), Relative Density (RD), and Importance Value (IV) for Shrub Species at all pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. The importance values were calculated as the average of relative height and relative density.

Species	AH	RH	DEN	RD	IV
Elaeagnus umbellata	1.74	12.06	509	14.97	13.51
Carya ovata	0.73	5.06	570	16.75	10.90
Lindera benzoin	0.73	5.06	386	11.35	8.20
Asimina triloba	0.90	6.24	220	6.47	6.35
Cornus florida	1.10	7.62	97	2.84	5.23
Nyssa sylvatica	0.67	4.64	196	5.77	5.21
Lonicera japonica	0.80	5.54	151	4.44	4.99
Corylus americana	1.02	7.07	82	2.41	4.74
Quercus velutina	0.38	2.63	220	6.45	4.54
Smilax glauca	1.00	6.93	63	1.84	4.39
Rosa multiflora	0.51	3.53	159	4.67	4.10
Sassafras albidum	0.72	4.99	108	3.17	4.08
Rubus sp.	0.43	2.98	175	5.14	4.06
Acer rubrum	0.91	6.31	46	1.34	3.82
Solidago sp.	0.54	3.74	97	2.85	3.30
Quercus imbricaria	0.52	3.60	73	2.13	2.87
Quercus alba	0.41	2.84	89	2.61	2.73
Osmunda cinnamomea	0.23	1.59	86	2.53	2.06
Robinia pseudo-acacia	0.22	1.52	32	0.94	1.23
Rhus vernix	0.28	1.94	13	0.38	1.16
Vitis sp.	0.30	2.08	7	0.21	1.14
Ilex montana	0.14	0.97	15	0.45	0.71
Eupatorium serotinum	0.07	0.49	7	0.21	0.35
Eupatorium sp.	0.04	0.28	2	0.05	0.16
Viburnum recognitum	0.04	0.28	1	0.03	0.15
Totals		100.00	3404	100.00	100.00

Table 8. Average height (AH, m), Relative height (RH), Density (DEN, stems/ha), Relative Density (RD), and Importance Value (IV) for Shrub Species at Pond 3 at McClintic Wildlife Management Area, Mason County, West Virginia. The importance values were calculated as the average of relative height and relative density.

1997

Species	AH	RH	DEN	RD	IV
Elaeagnus umbellata	1.67	16.68	767	51.44	34.06
Lonicera japonica	1.37	13.69	275	18.44	16.07
Asimina triloba	1.13	11.29	150	10.06	10.67
Corylus americana	1.45	14.49	50	3.35	8.92
Acer rubrum	1.15	11.49	67	4.49	7.99
Cornus florida	1.07	10.69	58	3.89	7.29
Smilax glauca	0.70	6.99	58	3.89	5.44
Rosa multiflora	0.60	5.99	42	2.82	4.41
Nyssa sylvatica	0.50	5.00	8	0.54	2.77
Solidago sp.	0.20	2.00	8	0.54	1.27
Sassafras albidum	0.17	1.70	8	0.54	1.12
Totals		100.00	1491	100.00	100.00

1998

Species	AH	RH	DEN	RD	IV
Elaeagnus umbellata	1.76	12.90	1014	52.57	32.73
Lonicera japonica	1.75	12.83	443	22.97	17.90
Asimina triloba	1.32	9.68	179	9.28	9.48
Cornus florida	2.14	15.69	36	1.87	8.78
Corylus americana	1.71	12.54	57	2.95	7.75
Acer rubrum	1.64	12.02	50	2.59	7.31
Nyssa sylvatica	1.21	8.87	57	2.95	5.91
Smilax glauca	1.11	8.14	36	1.87	5.00
Rosa multiflora	0.71	5.21	50	2.59	3.90
Viburnum recognitum	0.29	2.13	7	0.36	1.24
Totals		100.00	1929	100.00	100.00

Table 9. Average height (AH, m), Relative height (RH), Density (DEN, stems/ha), Relative Density (RD), and Importance Value (IV) for Shrub Species at Pond 4 at McClintic Wildlife Management Area, Mason County, West Virginia. The importance values were calculated as the average of relative height and relative density.

1997

Species	AH	RH	DEN	RD	IV
Lindera benzoin	1.08	7.57	1025	29.92	18.74
Asimina triloba	1.25	8.78	683	19.94	14.36
Rosa multiflora	1.24	8.71	500	14.59	11.65
Elaeagnus umbellata	1.59	11.17	350	10.22	10.69
Cornus florida	1.47	10.30	150	4.38	7.34
Osmunda cinnamomea	0.94	6.62	267	7.79	7.21
Quercus imbricaria	1.16	8.10	158	4.61	6.36
Lonicera japonica	1.20	8.41	92	2.69	5.55
Acer rubrum	1.13	7.88	42	1.23	4.55
Solidago sp.	0.67	4.67	50	1.46	3.06
Sassafras albidum	0.50	3.50	33	0.96	2.23
Corylus americana	0.50	3.50	17	0.50	2.00
Nyssa sylvatica	0.50	3.50	17	0.50	2.00
Smilax glauca	0.50	3.50	17	0.50	2.00
Rhus vernix	0.38	2.63	17	0.50	1.56
Rubus sp.	0.17	1.17	8	0.23	0.70
Totals		100.00	3426	100.00	100.00

1998

Species	AH	RH	DEN	RD	IV
Lindera benzoin	1.36	6.70	1257	24.61	15.65
Elaeagnus umbellata	1.81	8.91	779	15.25	12.08
Asimina triloba	1.62	8.00	650	12.73	10.36
Rosa multiflora	1.41	6.93	671	13.14	10.03
Lonicera japonica	1.47	7.24	379	7.42	7.33
Cornus florida	1.23	6.05	329	6.44	6.25
Osmunda cinnamomea	0.86	4.22	421	8.24	6.23
Rhus vernix	1.89	9.32	86	1.68	5.50
Ilex montana	1.12	5.51	121	2.37	3.94
Corylus americana	1.39	6.86	50	0.98	3.92
Smilax glauca	1.36	6.68	50	0.98	3.83
Quercus imbricaria	1.19	5.86	79	1.55	3.70
Acer rubrum	1.05	5.19	57	1.12	3.15
Rubus sp.	1.00	4.92	64	1.25	3.09
Nyssa sylvatica	0.90	4.45	86	1.68	3.07
Sassafras albidum	0.64	3.17	29	0.57	1.87
Totals		100.00	5108	100.00	100.00

Table 10. Average height (AH, m), Relative height (RH), Density (DEN, stems/ha), Relative Density (RD), and Importance Value (IV) for Shrub Species at Pond 13 at McClintic Wildlife Management Area, Mason County, West Virginia. The importance values were calculated as the average of relative height and relative density.

1997

Species	AH	RH	DEN	RD	IV
Carya ovata	1.35	13.47	925	35.24	24.35
Rubus sp.	1.09	10.86	492	18.74	14.80
Elaeagnus umbellata	1.49	14.84	158	6.02	10.43
Solidago sp.	1.01	10.09	258	9.83	9.96
Sassafras albidum	1.07	10.68	158	6.02	8.35
Lindera benzoin	0.72	7.21	225	8.57	7.89
Robinia pseudo-acacia	0.75	7.49	142	5.41	6.45
Corylus americana	0.50	4.99	133	5.07	5.03
Asimina triloba	0.58	5.82	42	1.60	4.96
Smilax glauca	0.63	6.24	50	1.90	4.07
Acer rubrum	0.58	5.82	42	1.60	3.71
Totals		100.00	2625	100.00	100.00

1998

Species	AH	RH	DEN	RD	IV
Carya ovata	1.33	8.67	907	25.81	17.24
Rubus sp.	1.17	7.66	836	23.79	15.73
Corylus americana	1.25	8.13	271	7.71	7.92
Elaeagnus umbellata	1.28	8.35	250	7.11	7.73
Sassafras albidum	1.14	7.42	279	7.94	7.68
Smilax glauca	1.51	9.85	164	4.67	7.26
Lindera benzoin	0.87	5.66	221	6.29	5.97
Solidago sp.	0.93	6.05	200	5.69	5.87
Robinia pseudo-acacia	1.03	6.72	114	3.24	4.98
Acer rubrum	0.93	6.10	79	2.25	4.17
Cornus florida	1.07	7.00	36	1.02	4.01
Asimina triloba	0.89	5.78	50	1.42	3.60
Vitis sp.	0.86	5.60	29	0.83	3.21
Eupatorium serotinum	0.57	3.73	57	1.62	2.68
Eupatorium sp.	0.36	2.33	14	0.40	1.36
Rosa multiflora	0.14	0.93	7	0.20	0.56
Totals		100.00	3514	100.00	100.00

Table 11. Average height (AH, m), Relative height (RH), Density (DEN, stems/ha), Relative Density (RD), and Importance Value (IV) for Shrub Species at Pond 14 at McClintic Wildlife Management Area, Mason County, West Virginia. The importance values were calculated as the average of relative height and relative density.

1997

Species	AH	RH	DEN	RD	IV
Carya ovata	1.53	11.35	1283	29.78	20.57
Quercus velutina	1.36	10.08	800	18.57	14.33
Nyssa sylvatica	1.17	8.67	675	15.67	12.17
Elaeagnus umbellata	2.18	16.20	350	8.12	12.16
Quercus alba	1.38	10.26	317	7.36	8.81
Sassafras albidum	1.18	8.74	250	5.80	7.27
Solidago sp.	0.83	6.19	167	3.88	5.03
Quercus imbricaria	0.79	5.88	158	3.67	4.77
Smilax glauca	0.92	6.80	75	1.74	4.27
Lindera benzoin	0.76	5.62	125	2.90	4.26
Corylus americana	0.67	4.95	42	0.97	2.96
Cornus florida	0.54	4.02	58	1.35	2.68
Acer rubrum	0.17	1.24	8	0.19	0.71
Totals		100.00	4308	100.00	100.00

1998

Species	AH	RH	DEN	RD	IV
Carya ovata	1.66	8.94	1443	29.88	19.41
Quercus velutina	1.67	9.00	957	19.82	14.41
Nyssa sylvatica	1.09	5.91	729	15.10	10.50
Elaeagnus umbellata	2.13	11.49	407	8.43	9.96
Quercus alba	1.87	10.10	393	8.14	9.12
Lindera benzoin	1.08	5.84	236	4.89	5.36
Quercus imbricaria	1.05	5.67	186	3.85	4.76
Cornus florida	1.30	7.01	107	2.22	4.61
Vitis sp.	1.50	8.10	29	0.60	4.35
Smilax glauca	1.29	6.94	50	1.04	3.99
Sassafras albidum	1.03	5.56	114	2.36	3.96
Solidago sp.	0.71	3.86	93	1.93	2.89
Corylus americana	0.71	3.86	36	0.75	2.30
Acer rubrum	0.64	3.47	21	0.43	1.95
Lonicera japonica	0.64	3.47	21	0.43	1.95
Asimina triloba	0.14	0.77	7	0.14	0.46
Totals		100.00	4829	100.00	100.00

at Pond 4 of these species. All three were found exclusively in a damp, shaded transect, with such wetland herbs as *Viola papilionacea* and *Sphagnum* sp.

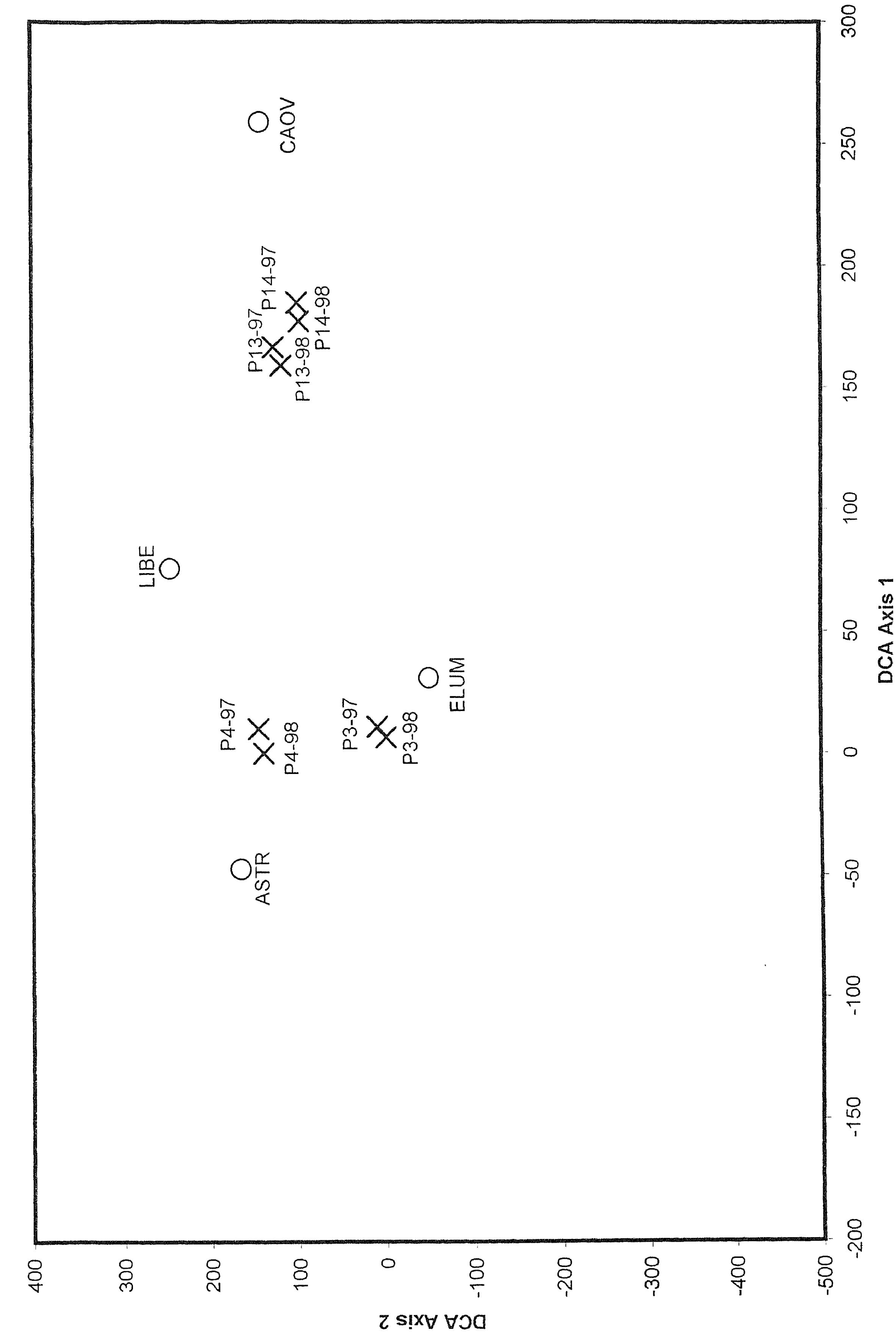
Close location of Ponds 13 and 14 to each other (Figure 3) may have played a role in sharing of common species. For example, *Carya ovata* and *Vitis* sp. were present only at these two sites (Tables 10 and 11). Ponds 13 and 14 were located next to one another, while Ponds 3 and 4 were located further from each other and from Ponds 13 and 14 (Figure 3).

Despite year to year changes in overall importance values for shrubs by species and location, the most dominant species at each pond site in 1997 remained dominant in 1998. *Elaeagnus umbellata* was most dominant at Pond 3 (Table 8), *Lindera benzoin* at Pond 4 (Table 9), *Carya ovata* at Pond 13 (Table 10), and *Carya ovata* at Pond 14 (Table 11).

Loss and gain of some species occurred on all ponds over the two-year study. At Pond 3, *Sassafras albidum* and *Solidago* sp. were present in 1997 but not 1998, and *Viburnum recognitum* was present in 1998 but not 1997 (Table 8). Loss of *S. albidum* and *Solidago* sp. most likely can be explained by mortality of the species; neither was present in great amounts in 1997 and thus contributed a very small importance to the shrub layer in 1997 (Table 8). *Viburnum recognitum*, present in 1998 but not 1997, may be explained by height growth from 1997 to 1998, making the species advance into the shrub layer. Because shrubs less than 1.0 m in height were not tabulated, the species could have been slightly less than 1 m in 1997 and thus not recorded. At Pond 4, *Ilex montana* was present only in 1998, while *Solidago* sp. was present only in 1997 (Table 9). *Ilex montana* was less than 1 m in height during 1997, and was observed to have a significant increase in height in 1998 (Table 9). *Solidago* sp. is an annual species, so death during 1997 may have resulted either in the species failing to be present in 1998 or not tall enough to be classified in the shrub layer. At Pond 13, *Cornus florida*, *Eupatorium serotinum*, *Eupatorium* sp., *Rosa multiflora*, and *Vitis* sp. were present only in 1998 (Table 10). *Cornus florida*, *R. multiflora*, and *Vitis* sp. probably were not tall enough to be classified as shrubs in 1997, while *E. serotinum* and *Eupatorium* sp. either were not tall enough in 1997 to be shrubs, or because of their growth habit as annuals (Strausbaugh and Core 1977), may have only seeded and grown during 1998. At Pond 14, *A. triloba*, *L. japonica*, and *Vitis* sp. were only present in 1998, probably explained by lower heights in 1997 (Table 11).

Within each pond site, DCA ordination points for 1997 were very similar to those for 1998, indicating little overall change in communities between years (Figure 6). The four most dominant shrub species, *Elaeagnus umbellata* (ELUM), *Carya ovata* (CAOV), *Lindera benzoin* (LIBE), and *Asimina triloba* (ASTR) are graphed with pond site ordination points. *Elaeagnus umbellata*, found at all ponds, had highest importance values at Pond 3 (Table 8) and had least importance at Pond 13 (Table 10). The overall importance value for the species was lower in 1998 than 1997 for Ponds 3, 13, and 14, but higher for Pond 4. *Carya ovata* was present at Ponds 13 and 14 (Tables 9 and 10), explaining ordination far away from Ponds 3 and 4 (Figures 6 and 7). Of the two ponds in which *C. ovata* was present, it was of highest importance at Pond 13 in 1997 (Table 10). *Lindera benzoin* had highest importance values at Pond 4 during 1997 but was found with greatest importance at Pond 4 both years (Table 9). The species was not found at Pond 3 for either year, explaining ordination furthest from that pond site (Figure

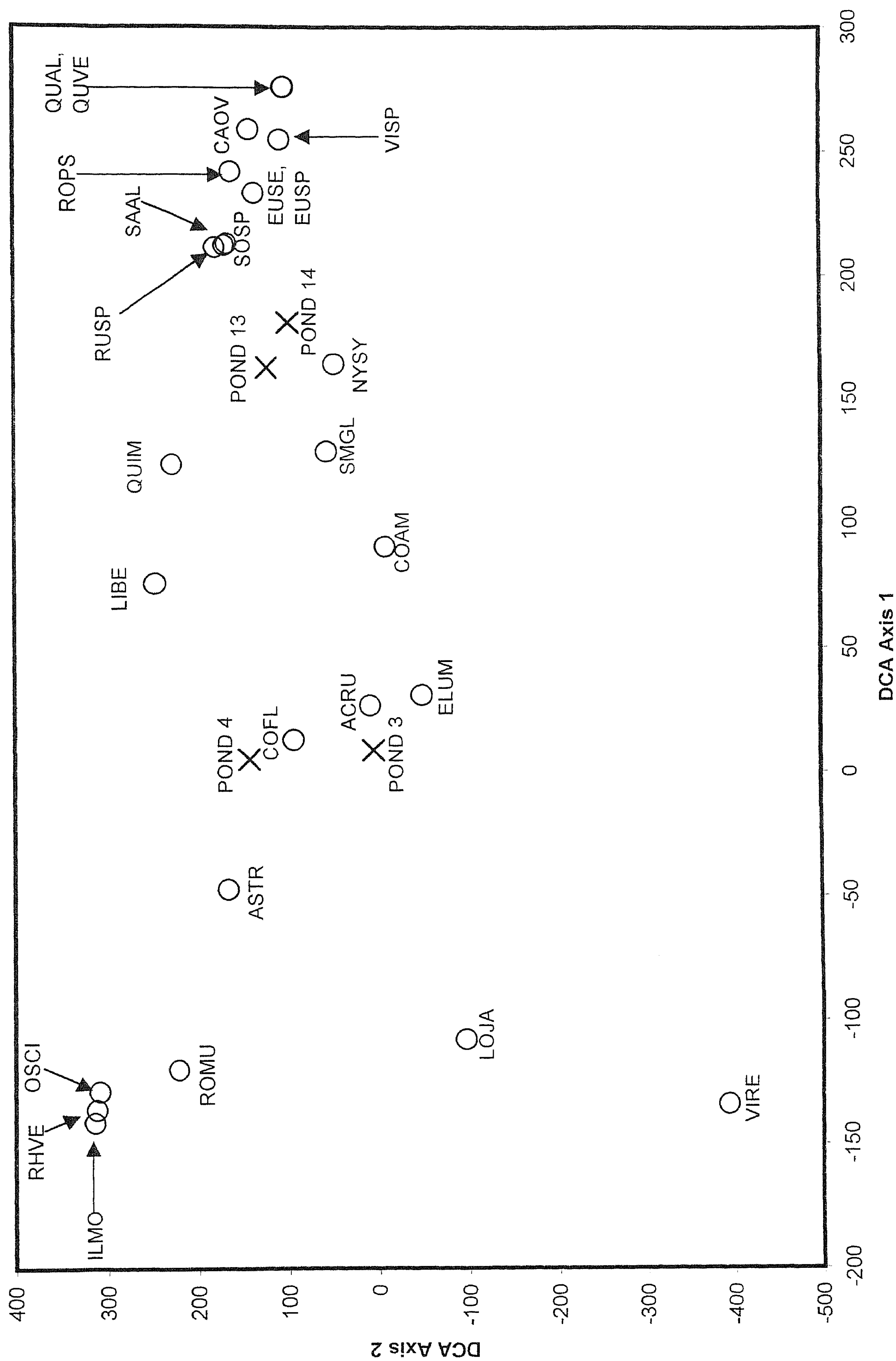
Figure 6. Detrended correspondence analysis (DCA) of sampled shrub communities in 1997 and 1998 at McClintic Wildlife Management Area, Mason County, West Virginia, by pond site location, with dominant species. Code names for dominant species: ASTR = *Asimina triloba*; LIBE = *Lindera benzoin*; ELUM = *Elaeagnus umbellata*; CAOV = *Carya ovata*.


CAOV
P14-97
P14-98
P13-97
P13-98
LIBE
ELUM
P4-97
P4-98
P3-97
P3-98
ASTR
DCA Axis 1
DCA Axis 2
300
250
200
150
100
50
0
-50
-100
-150
-200
400
300
200
100
0
-100
-200
-300
-400
-500

6). *Asimina triloba* was most dominant at Pond 4 (Table 9) and Pond 3 (Table 8), with much less importance at Ponds 13 and 14 (Tables 10 and 11, respectively). Such importance values are consistent with *A. triloba* having closest ordinations with Ponds 3 and 4 and being further from Ponds 13 and 14 (Figure 6). At all ponds but 14, *A. triloba* had a higher importance value in 1997 than 1998 (Tables 8-11), consistent with an ordination closer to the 1997 year (Figure 6).

Ordination points of all shrub species showed that the closer a species was to a pond site on the axes, the closer the relationship between the species and the location (Figure 7). *Osmunda cinnamomea* (OSCI), *Rhus vernix* (RHVE), and *Ilex montana* (ILMO) were present at Pond 4 exclusively (Table 9). *Viburnum recognitum* (VIRE) was found at Pond 3 only (Table 8), while *Lonicera japonica* (LOJA) and *Asimina triloba* (ASTR), were of greatest importance at Ponds 3 and 4, explaining their close ordination with the pond sites. Species clustering in the center of the graph, such as *Cornus florida*, *Acer rubrum*, *Elaeagnus umbellata*, *Quercus imbricaria*, *Corylus americana*, and *Smilax glauca* were found at all four ponds, explaining their respective ordination locations. *Lindera benzoin* was not found in either year at Pond 3 (Table 8) but was at the other three pond sites, explaining ordination in the center of the graph yet further removed from Pond 3. *Nyssa sylvatica* had highest importance at Pond 14 (Table 11). Even though *Solidago* sp. and *Sassafras albidum* were present at all four pond sites, they had highest importance values at Ponds 13 and 14 (Tables 10 and 11), which support ordination points closer to those pond sites. *Rubus* sp. was not present at Pond 3 or 14 and had highest importance values at Pond 13 (Table 10). *Robinia pseudo-acacia* was

Figure 7. Detrended correspondence analysis (DCA) of shrub species at McClintic Wildlife Management Area, Mason County, West Virginia, with ordination of all species, together with average pond site ordinations for 1997 and 1998. See Table 1 for species code names.


DCA Axis 1
DCA Axis 2
-200
-150
-100
-50
0
50
100
150
200
250
300
400
300
200
100
0
-100
-200
-300
-400
-500
QUAL,
QUVE
CAOV
VISP
ROPS
EUSE,
EUSP
SAAL
SOSP
RUSP
POND 14
POND 13
NYSY
SMGL
QUIM
LIBE
COAM
ACRU
ELUM
POND 4
COFL
POND 3
ASTR
LOJA
OSCI
ROMU
RHVE
ILMO
VIRE

only present at Pond 13, supporting ordination closest to that site. *Carya ovata* was found only at Pond 13 and 14, and was of highest importance at Pond 13 in 1997 (Table 10). *Vitis* sp. was found at Ponds 13 and 14, but was of greatest importance at Pond 14 (Table 11). *Eupatorium serotinum* and *Eupatorium* sp. were only present at Pond 13 in 1998, while *Quercus alba* and *Q. velutina* was found only at Pond 14, with slightly higher importance values in 1998.

As in the tree community, DCA suggests that shrub species determined locations of pond site ordinations. Importance and distribution of species served as determining factors separating pond site ordinations. As with the tree stratum, site characteristics and conditions may have affected distribution of species. While these are speculative assumptions, they may help to understand changes in species abundance and importance over time and among pond sites. An important consideration to be made in interpreting DCA axes is that a decrease in importance for a species is not a direct indication of stem mortality (loss of height or density). Even though some species may have experienced increases in height and density, importance values are based on relative numbers. As a result, an increase in one species may lead to a decline in importance of another species.

Herbaceous-Layer Analysis

Ground-level vegetation, though only producing a small amount of forest biomass, is important in a number of ecosystem processes because it has a high proportion of leafy material and low proportion of biomass gain by woody tissue (Ford and Newbould 1977, Ovington 1962). Many ecological studies focus on the herbaceous layer because it is the most species-rich stratum (Walters and Williams 1999). However, performance and survival of some herbaceous species may be directly affected by forest growth. Tree cover intercepts radiation and precipitation, two environmental factors that influence growth of ground vegetation (Ford and Newbould 1977, Blackman and Rutter 1946); as a result, consideration of the herbaceous stratum is essential in a comprehensive vegetation study.

The herbaceous layer is important in initiating competition among seedlings of potential dominant overstory species, and also has been used as an indicator of general forest site quality (Gilliam et al. 1995, Pregitzer and Barnes 1982, Cserep et al. 1991). Energy and nutrient conditions in the herbaceous layer may determine success or failure of reproduction of potentially dominant tree species (Siccama and Bormann 1970). According to Gilliam et al. (1994), the herb layer has two distinct types of species: resident and transient species. Resident species are confined to the herbaceous growth habit, such as annuals, perennial herbs, and low-growing shrubs. Transient species have the potential to emerge from the herbaceous layer into higher strata. Herbs (and shrubs) influence future tree canopy composition, and herbs can have direct effect on tree seedling establishment (Davison and Forman 1982). Some common herbs found in eastern deciduous forests are *Parthenocissus quinquefolia*, *Vitis* sp., and *Smilax* sp. (Braun 1950), all found at MWMA.

All four herbaceous communities showed increases in total mean cover from 1997 to 1998 (Tables 12 and 13). Pond 13 showed the greatest increase in total mean cover of herbaceous vegetation from 1997 to 1998. Increases (given in percents) were 13.45 for Pond 3, 29.65 for Pond 4, 34.30 for Pond 13, and 19.16 for Pond 14.

One-way analysis of variance on mean cover of herbaceous species showed that in 1997, Ponds 3 and 14 were not significantly different ($P<0.10$) with regard to mean herbaceous cover (Table 14). Pond 4 was significantly different from Ponds 3 and 14, while Pond 13 was not significantly different from any of the other pond sites. In 1998, as in 1997, Ponds 3 and 14 were not significantly different, and Ponds 4 and 13 were not significantly different. However, in 1998, Pond 13 was significantly different from Ponds 3 and 14 (note change of superscript letters from ab in 1997 to b in 1998). Such results indicate that Ponds 3 and 14, and 4 and 13, had relatively similar amounts of mean cover with regard to the herbaceous layer.

Importance values for herbaceous species were calculated as relative cover. The five most important herbs over the two-year study were *Lonicera japonica*, *Panicum* sp., *Sphagnum* sp., *Danthonia spicata*, and *Spiraea tomentosa* (Tables 15, 16, and 17). An important consideration to be made in analyzing dominant species, however, is that presence and abundance of a particular species may have varied greatly among ponds. A

Table 12. Mean cover (percent) for herbaceous vegetation at four ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997. A dash indicates the species was not present on a particular pond.

Species	Pond 3	Pond 4	Pond 13	Pond 14	Species	Pond 3	Pond 4	Pond 13	Pond 14
Acer rubrum	0.18	0.17	1.42	0.17	*Platanus occidentalis*	-	-	-	0.03
Asplenium platyneuron	0.28	0.01	-	-	*Polystichum acrostichoides*	-	2.68	-	-
Asimina triloba	0.08	-	0.11	-	*Polygonum hydropiperoides*	1.79	0.13	2.26	0.61
Athyrium pycnocarpon	0.03	-	-	-	*Polygonum sagittatum*	-	0.07	1.35	-
Carya ovata	-	-	2.24	1.76	*Potentilla simplex*	-	-	2.14	0.22
Carex sp.	0.04	-	-	-	*Prunus serotina*	0.14	0.63	0.28	0.14
Cornus florida	1.31	0.83	0.01	1.15	*Quercus alba*	0.13	-	0.01	1.76
Cunila origanoides	-	-	-	0.17	*Quercus imbricaria*	0.25	0.17	0.40	1.57
Danthonia spicata	0.26	0.28	0.51	6.21	*Quercus palustris*	0.57	0.04	0.04	0.07
Diervilla lonicera	0.49	1.45	0.60	1.03	*Quercus velutina*	0.15	-	-	1.28
Elaeagnus umbellata	-	0.46	0.14	-	*Rhus radicans*	0.28	1.54	4.58	0.35
Eupatorium serotinum	-	0.06	0.06	-	*Rosa multiflora*	0.42	4.11	0.03	-
Juncus effusus	0.38	-	3.54	2.17	*Rubus hispidus*	0.03	6.58	0.43	-
Lemna minor	1.39	-	-	-	*Rubus* sp.	0.67	0.03	2.03	0.14
Lindera benzoin	0.09	0.61	0.64	0.46	*Sassafras albidum*	0.89	0.89	0.32	2.18
Lonicera japonica	6.97	2.21	9.13	4.50	*Scirpus* sp.	-	-	0.76	-
Ludwigia palustris	0.29	-	-	0.46	*Smilax glauca*	1.04	0.33	0.56	2.44
Lycopodium flabelliforme	1.75	-	-	-	*Solidago* sp.	0.14	0.01	0.72	0.56
Lycopus virginicus	1.28	-	-	0.96	*Sphagnum* sp.	-	14.17	-	-
Nyssa sylvatica	-	-	0.20	0.17	*Spiraea tomentosa*	9.32	-	-	0.01
Onoclea sensibilis	1.06	2.17	-	-	*Viburnum prunifolium*	-	0.07	0.21	0.10
Parthenocissus quinquefolia	0.39	1.26	6.11	4.00	*Viola papilionacea*	-	0.82	-	-
Panicum sp.	3.60	3.07	1.32	0.65	Totals	35.65	44.87	42.14	35.31
Phytolacca americana	-	0.04	-	-					

Table 13. Mean cover (percent) for herbaceous vegetation on four ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1998. A dash indicates the species was not present at a particular pond.

Species	Pond 3	Pond 4	Pond 13	Pond 14	Species	Pond 3	Pond 4	Pond 13	Pond 14
Acer rubrum	0.25	0.06	1.47	0.40	*Panicum* sp.	10.17	13.22	1.25	1.13
Aesculus glabra	-	0.02	0.04	-	*Phytolacca americana*	0.06	-	-	-
Alnus serrulata	-	-	0.42	-	*Polystichum acrostichoides*	-	4.33	-	-
Asplenium platyneuron	1.06	0.81	-	-	*Polygonum hydropiperoides*	0.60	1.10	5.18	0.19
Asimina triloba	0.12	-	-	-	*Polygonum sagittatum*	-	-	4.44	-
Athyrium pycnocarpon	0.29	0.48	-	-	*Potentilla simplex*	-	-	9.80	1.92
Carex frankii	-	0.72	-	-	*Prunus serotina*	1.01	1.40	1.01	0.25
Carya ovata	-	-	4.51	2.94	*Quercus alba*	0.38	-	-	2.97
Carex sp.	0.12	0.60	1.19	0.36	*Quercus imbricaria*	0.48	-	2.08	1.85
Chimaphilla maculata	-	0.04	-	-	*Quercus palustris*	0.62	-	-	0.09
Corylus americana	-	-	3.57	-	*Quercus velutina*	0.16	-	-	1.42
Cornus florida	2.52	0.45	0.16	2.67	*Rhus radicans*	0.17	1.15	7.29	0.50
Danthonia spicata	0.57	-	0.44	15.48	*Rosa multiflora*	2.13	5.92	-	0.04
Diervilla lonicera	0.21	0.95	0.12	-	*Robinia pseudo-acacia*	-	-	0.36	-
Elaeagnus umbellata	-	2.50	-	-	*Rubus hispidus*	-	6.08	4.13	-
Eupatorium serotinum	-	-	0.86	-	*Rubus* sp.	1.80	3.51	5.55	-
Juncus effusus	0.82	1.37	2.19	9.23	*Sassafras albidum*	0.67	0.06	1.96	3.81
Lindera benzoin	0.25	5.61	1.18	0.55	*Sambucus canadensis*	-	0.02	-	-
Lonicera japonica	5.95	3.20	10.55	3.56	*Scirpus* sp.	-	-	0.77	-
Ludwigia palustris	0.83	-	-	-	*Setaria faberii*	-	-	0.10	-
Lycopus americanus	-	-	1.55	-	*Smilax glauca*	1.21	0.83	0.86	2.32
Lycopodium flabelliforme	2.05	-	-	-	*Solidago* sp.	-	0.06	0.46	0.63
Lycopus virginicus	3.15	-	0.06	0.24	*Sphagnum* sp.	-	15.90	-	-
Morus alba	-	0.31	-	0.37	*Spiraea tomentosa*	9.89	-	0.20	0.01
Nyssa sylvatica	0.01	-	-	0.30	*Viburnum prunifolium*	-	0.36	0.81	0.04
Onoclea sensibilis	1.33	1.49	-	-	*Viola papilionacea*	-	1.57	-	-
Parthenocissus quinquefolia	0.26	0.67	2.09	0.07	*Vitis* sp.	-	0.08	-	0.14
					Totals	49.14	74.86	76.64	53.45

Table 14. Mean cover of herbaceous layer of four ponds sampled at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. Values given are means ± 1 S.E. Means with the same superscript letter are not significantly different at the P<0.10 level.

1997 Pond	Mean Cover (%)
3	35.65 ± 3.13^{a}
4	44.87 ± 3.64^{b}
13	42.14 ± 3.70^{ab}
14	35.31 ± 3.36^{a}

1998 Pond	Mean Cover (%)
3	49.14 ± 3.35^{a}
4	74.86 ± 3.53^{b}
13	76.64 ± 3.71^{b}
14	53.45 ± 3.56^{a}

Table 15. Overall importance values (average relative cover) for herbaceous species at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998.

Species	Importance Value	Species	Importance Value
Lonicera japonica	11.96	*Solidago* sp.	0.70
Panicum sp.	8.00	*Elaeagnus umbellata*	0.59
Sphagnum sp.	6.60	*Corylus americana*	0.58
Danthonia spicata	6.35	*Asplenium platyneuron*	0.51
Spiraea tomentosa	5.82	*Lemna minor*	0.49
Juncus effusus	4.90	*Viola papilionacea*	0.49
Parthenocissus quinquefolia	4.25	*Ludwigia palustris*	0.48
Rubus hispidus	3.66	*Quercus palustris*	0.43
Rhus radicans	3.55	*Carex* sp.	0.42
Rosa multiflora	2.84	*Scirpus* sp.	0.36
Rubus sp.	2.84	*Viburnum prunifolium*	0.32
Sassafras albidum	2.82	*Lycopus americanus*	0.25
Polygonum hydropiperoides	2.78	*Nyssa sylvatica*	0.19
Potentilla simplex	2.76	*Eupatorium serotinum*	0.17
Carya ovata	2.71	*Athyrium pycnocarpon*	0.16
Smilax glauca	2.63	*Morus alba*	0.14
Cornus florida	2.47	*Carex frankii*	0.12
Lindera benzoin	1.87	*Asimina triloba*	0.09
Quercus imbricaria	1.70	*Alnus serrulata*	0.07
Lycopus virginicus	1.66	*Cunila origanoides*	0.06
Onoclea sensibilis	1.56	*Robinia pseudo-acacia*	0.06
Polystichum acrostichoides	1.47	*Vitis* sp.	0.05
Quercus alba	1.46	*Phytolacca americana*	0.03
Diervilla lonicera	1.35	*Setaria faberii*	0.02
Lycopodium flabelliforme	1.14	*Aesculus glabra*	0.01
Polygonum sagittatum	1.14	*Chimaphilla maculata*	0.01
Prunus serotina	1.07	*Platanus occidentalis*	0.01
Acer rubrum	1.00	*Sambucus canadensis*	0.01
Quercus velutina	0.88		

Table 16. Relative cover (percent) for herbaceous vegetation at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997. A dash indicates the species was not present on a particular pond.

Species	Overall	Pond 3	Pond 4	Pond 13	Pond 14	Species	Overall	Pond 3	Pond 4	Pond 13	Pond 14
Lonicera japonica	14.72	19.56	4.92	21.65	12.75	*Acer rubrum*	1.18	0.50	0.37	3.37	0.47
Sphagnum sp.	7.90	-	31.58	-	-	*Lindera benzoin*	1.11	0.24	1.36	1.52	1.30
Parthenocissus quinquefolia	7.43	1.09	2.80	14.50	11.33	*Quercus velutina*	1.01	0.43	-	-	3.62
Spiraea tomentosa	6.55	26.14	-	-	0.04	*Lemna minor*	0.97	3.89	-	-	-
Panicum sp.	5.48	10.09	6.84	3.13	1.85	*Solidago* sp.	0.93	0.39	0.03	1.71	1.58
Danthonia spicata	5.03	0.71	0.62	1.22	17.58	*Polygonum sagittatum*	0.84	-	0.16	3.20	-
Rhus radicans	4.02	0.78	3.44	10.88	0.99	*Prunus serotina*	0.71	0.39	1.40	0.66	0.37
Rubus hispidus	3.94	0.08	14.67	1.02	-	*Ludwigia palustris*	0.53	0.82	-	-	1.30
Juncus effusus	3.90	1.06	-	8.40	6.13	*Quercus palustris*	0.50	1.60	0.09	0.10	0.20
Polygonum hydropiperoides	3.10	5.03	0.28	5.37	1.73	*Viola papilionacea*	0.46	-	1.82	-	-
Smilax glauca	2.98	2.92	0.74	1.32	6.92	*Scirpus* sp.	0.45	-	-	1.81	-
Sassafras albidum	2.85	2.50	1.98	0.75	6.17	*Elaeagnus umbellata*	0.34	-	1.02	0.33	-
Rosa multiflora	2.60	1.17	9.17	0.07	-	*Nyssa sylvatica*	0.23	-	-	0.46	0.47
Carya ovata	2.57	-	-	5.30	4.99	*Viburnum prunifolium*	0.23	-	0.16	0.49	0.27
Diervilla lonicera	2.23	1.37	3.22	1.42	2.91	*Asplenium platyneuron*	0.20	0.78	0.03	-	-
Cornus florida	2.20	3.66	1.85	0.03	3.27	*Asimina triloba*	0.12	0.23	-	0.26	-
Onoclea sensibilis	1.95	2.96	4.83	-	-	*Cunila origanoides*	0.12	-	-	-	0.47
Rubus sp.	1.78	1.87	0.06	4.81	0.39	*Eupatorium serotinum*	0.07	-	0.13	0.13	-
Quercus imbricaria	1.62	0.70	0.37	0.96	4.44	*Carex* sp.	0.03	0.12	-	-	-
Lycopus virginicus	1.58	3.59	-	-	2.71	*Phytolacca americana*	0.02	-	0.09	-	-
Polystichum acrostichoides	1.49	-	5.97	-	-	*Platanus occidentalis*	0.02	-	-	-	0.08
Potentilla simplex	1.43	-	-	5.07	0.63	*Athyrium pycnocarpon*	0.02	0.08	-	-	-
Quercus alba	1.34	0.35	-	0.03	4.99	Totals	100.00	100.00	100.00	100.00	100.00
Lycopodium flabelliforme	1.23	4.91	-	-	-						

Table 17. Relative cover (percent) for herbaceous vegetation at four ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1998. A dash indicates the species was not present on a particular pond.

Species	Overall	Pond 3	Pond 4	Pond 13	Pond 14	Species	Overall	Pond 3	Pond 4	Pond 13	Pond 14
Panicum sp.	10.53	20.70	17.66	1.63	2.11	*Carex* sp.	0.82	0.24	0.80	1.55	0.67
Lonicera japonica	9.20	12.11	4.28	13.76	6.66	*Asplenium platyneuron*	0.81	2.16	1.08	-	-
Danthonia spicata	7.68	1.17	-	0.57	28.96	*Quercus velutina*	0.74	0.32	-	-	2.64
Juncus effusus	5.91	1.67	1.83	2.86	17.26	*Viola papilionacea*	0.53	-	2.10	-	-
Sphagnum sp.	5.31	-	21.23	-	-	*Lycopus americanus*	0.51	-	-	2.02	-
Spiraea tomentosa	5.10	20.13	-	0.26	0.02	*Solidago* sp.	0.47	-	0.08	0.61	1.18
Potentilla simplex	4.09	-	-	12.78	3.58	*Diervilla lonicera*	0.47	0.44	1.27	0.15	-
Rubus sp.	3.90	3.66	4.69	7.24	-	*Ludwigia palustris*	0.43	1.70	-	-	-
Rubus hispidus	3.38	-	8.13	5.39	-	*Viburnum prunifolium*	0.40	-	0.48	1.06	0.07
Rhus radicans	3.08	0.34	1.54	9.51	0.94	*Quercus palustris*	0.36	1.26	-	-	0.18
Rosa multiflora	3.08	4.34	7.90	-	0.07	*Athyrium pycnocarpon*	0.31	0.58	0.64	-	
Carya ovata	2.85	-	-	5.89	5.50	*Eupatorium serotinum*	0.28	-	-	1.12	-
Sassafras albidum	2.78	1.36	0.08	2.56	7.13	*Morus alba*	0.28	-	0.41	-	0.69
Cornus florida	2.73	5.13	0.60	0.20	4.99	*Scirpus* sp.	0.25	-	-	1.01	-
Lindera benzoin	2.64	0.51	7.49	1.54	1.02	*Carex frankii*	0.24	-	0.96	-	-
Polygonum hydropiperoides	2.45	1.21	1.46	6.76	0.36	*Nyssa sylvatica*	0.15	0.02	-	-	0.56
Smilax glauca	2.26	2.47	1.11	1.12	4.34	*Alnus serrulata*	0.14	-	-	0.54	-
Quercus imbricaria	1.79	0.97	-	2.72	3.46	*Robinia pseudo-acacia*	0.12	-	-	0.47	-
Lycopus virginicus	1.74	6.42	-	0.08	0.44	*Vitis* sp.	0.10	-	0.11	-	0.27
Quercus alba	1.58	0.78	-	-	5.55	*Asimina triloba*	0.06	0.24	-	-	-
Polystichum acrostichoides	1.45	-	5.79	-	-	*Setaria faberii*	0.03	-	-	0.12	-
Polygonum sagittatum	1.45	-	-	5.79	-	*Phytolacca americana*	0.03	0.12	-	-	-
Prunus serotina	1.43	2.06	1.88	1.32	0.47	*Aesculus glabra*	0.02	-	0.03	0.05	-
Onoclea sensibilis	1.18	2.71	1.99	-	-	*Chimaphilla maculata*	0.01	-	0.05	-	-
Corylus americana	1.17	-	-	4.66	-	*Sambucus canadensis*	0.01	-	0.03	-	-
Parthenocissus quinquefolia	1.07	0.53	0.89	2.73	0.14						
Lycopodium flabelliforme	1.04	4.17	-	-	-						
Elaeagnus umbellata	0.84	-	3.34	-	-						
Acer rubrum	0.82	0.51	0.08	1.92	0.76	Total	100.00	100.00	100.00	100.00	100.00

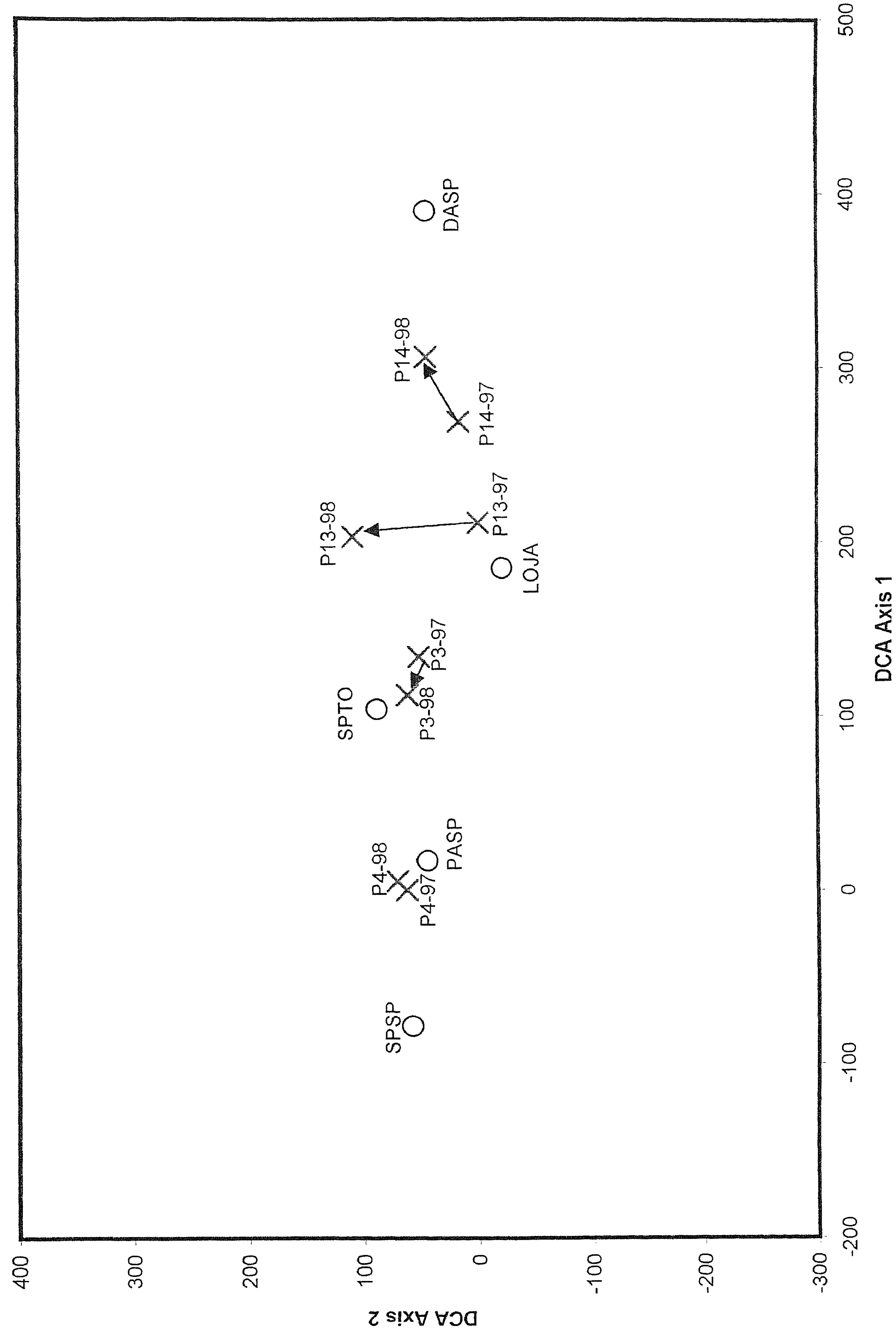
species high in abundance at one pond may have been present in lesser amounts at other ponds or may have not been present at all. For example, *Spiraea tomentosa* was found exclusively at Pond 4 both years (Tables 16 and 17). As a result, some dominant herbs, judged by importance values, may not be dominant over all ponds. Indeed, among all four pond sites, there were different dominant herbs, with some species dominant at one pond site being of lesser importance elsewhere; such a phenomenon may be due to differences in site specificity.

For both years, dominant species present were: *Lonicera japonica* and *Spiraea tomentosa* at Pond 3; *Panicum* sp., *Rubus hispidus*, and *Sphagnum* sp. at Pond 4; *Lonicera japonica* and *Rhus radicans* at Pond 13; and *Danthonia spicata* and *Lonicera japonica* at Pond 14 (Tables 16 and 17). The presence of dominant herbaceous species at each pond site was generally consistent with observed conditions at each location. *Lonicera japonica* and *Rhus radicans* are species commonly found in woods and thickets (Strausbaugh and Core 1977); areas where these species were most dominant were found to be drier and more conducive to growth of vines and vegetation common among dense woods and thickets. Similarly, *Danthonia spicata*, a dominant herb species at Pond 14, is found in dry soil (observed at Pond 14) throughout the state, and its presence usually indicates poor land (Strausbaugh and Core 1977). *Spiraea tomentosa* is found in swamps and low ground (Strausbaugh and Core 1977), consistent with areas at Pond 3 where the species was found; such areas were closer to the pond (not in upland areas). *Rubus hispidus*, found mostly at Pond 4, is found in low and boggy places (Strausbaugh and Core 1977), as is *Sphagnum* sp., consistent with observations of this study. Pond 4 was the most swampy and boggy pond of any sampled; herb vegetation was very fragile due to moisture, and any disturbance in the area, such as human footprints, could significantly disturb the area, so caution had to be used to prevent destruction and disturbance. Of the four ponds, Ponds 13 and 14, located in close proximity to each other (side by side), had the least shading and did not have as much canopy structure to block sun; this may help to explain prevalence of more dry-tolerant species on those ponds and a tendency for swamp-like species to be at Ponds 3 and 4. Close association of some species with others may be partly explained because the herbaceous environment may be spatially heterogeneous, and some areas of a given land area may support herbaceous plant life better than other areas and show positive correlation among species. Species that exhibit similar growth requirements may show positive correlation (Muller 1990).

DCA pond site ordinations for herbs in 1997 and 1998 showed that Ponds 4 and 14 were most dissimilar (Figure 8). Overall yearly changes were minor and indicated that from sampling of two consecutive growing seasons, dramatic changes in herbaceous vegetation did not occur.

Graphed with pond site ordinations are the five most dominant herbs: *Lonicera japonica* (LOJA), *Panicum* sp. (PASP), *Sphagnum* sp. (SPSP), *Danthonia spicata* (DASP), and *Spiraea tomentosa* (SPTO) (Figure 8). *Lonicera japonica* was of greatest importance at Ponds 3 and 13, of lesser importance at Pond 14, and of least importance at Pond 4 (Tables 16 and 17). All pond sites had higher importance values of *L. japonica* in 1997, resulting in ordination of the species closest to 1997 pond ordinations. *Panicum* sp., present at all pond sites, was of highest importance at Ponds 3 and 4, with higher importance in 1998 (Tables 16 and 17), further supported by ordination closest to Ponds

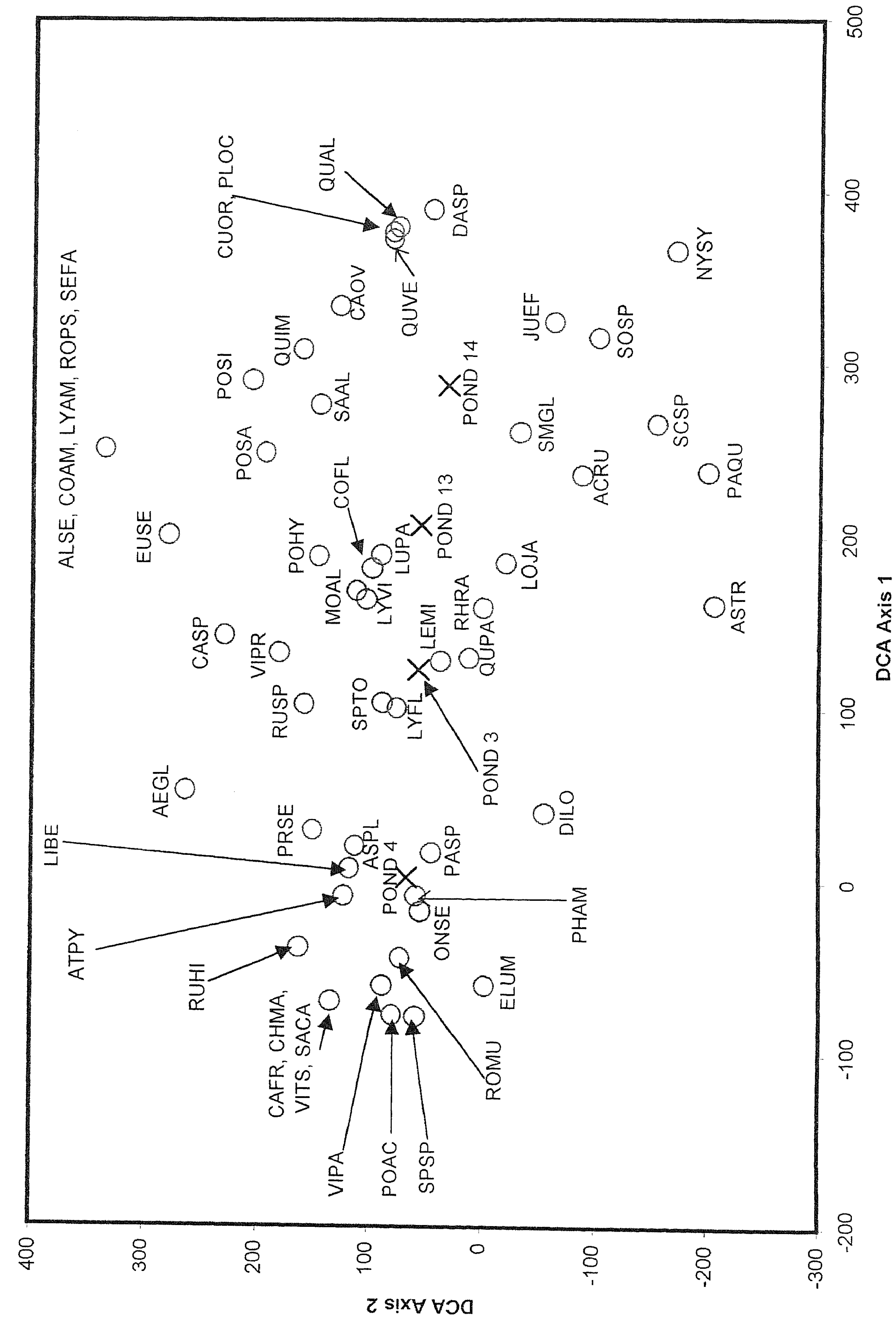
Figure 8. Detrended correspondence analysis (DCA) of herbaceous vegetation in 1997 and 1998 at McClintic Wildlife Management Area, Mason County, West Virginia, by pond site location, with dominant species. Code names for dominant species: SPSP = *Sphagnum* sp.; PASP = *Panicum* sp.; LOJA = *Lonicera japonica*; DASP = *Danthonia spicata*.


DCA Axis 1
DCA Axis 2
DASP
P14-98
P14-97
P13-98
P13-97
LOJA
SPTO
P3-97
P3-98
PASP
P4-98
P4-97
SPSP
-200
-100
0
100
200
300
400
500
400
300
200
100
0
-100
-200
-300

3 and 4. Even though *Sphagnum* sp. was a dominant species, it was present only at Pond 4 (Tables 16 and 17); high importance for the species at the pond site resulted in it being a dominant species. As a result of distribution of the species, the ordination points were near Pond 4, far removed from all other ponds and species. *Danthonia spicata* was of greatest importance at Pond 14 during 1998 (Table 17), evidenced by ordination closest to Pond 14 1998 values. A far-removed ordination point is further explained because relative importance of *D. spicata* was much higher at Pond 14 than other sites. *Spiraea tomentosa* was of greatest importance at Pond 3 and had a higher importance value in 1997 (Tables 16 and 17). The species was also found at Pond 13 in 1998 (Table 17), explaining ordination closest to 1998 pond site ordinations.

From results of ordination of all herbaceous species, many showed closer relationships with some ponds than with others (Figure 9). As specific examples, *Sphagnum* sp. (SPSP), *Rosa multiflora* (ROMU), *Viola papilionacea* (VIPA), *Rubus hispidus* (RUHI), and *Lindera benzoin* (LIBE) were most closely associated with Pond 4. Species of *Viola* have been found in riparian forests in Pennsylvania (Walters and Williams 1999), so more close association of *V. papilionacea* with the swampy, wet conditions of Pond 4 are consistent with observations from other studies. *Viola papilionacea* was found almost exclusively on Pond 4, with only a small amount on Pond 14 during 1998 (Tables 16 and 17). *Rosa multiflora* was found in greatest amounts on Pond 4, followed by Pond 3. *Rubus hispidus* was found mostly on Pond 4, with smaller amounts occasionally present on Ponds 13 and 3. *Lindera benzoin* showed a higher importance value on Pond 4 than other ponds in 1998 (Table 17). Consistent with other DCA observations, *Rosa multiflora* had greater overall importance in 1997 than 1998 at

Figure 9. Detrended correspondence analysis (DCA) of herbaceous vegetation during 1997 and 1998 at McClintic Wildlife Management Area, Mason County, West Virginia, with ordinations of all species, together with average pond site ordinations for both years. See Table 1 for species code names.



DCA Axis 1
DCA Axis 2
-200
-100
0
100
200
300
400
500
-300
-200
-100
0
100
200
300
400
ALSE, COAM, LYAM, ROPS, SEFA
CUOR, PLOC
QUAL
DASP
QUVE
NYSY
CAOV
QUIM
POSI
JUEF
SOSP
POND 14
SAAL
POSA
SMGL
SCSP
ACRU
PAQU
COFL
POND 13
EUSE
POHY
LUPA
LYVI
MOAL
LOJA
RHRA
ASTR
CASP
VIPR
LEMI
QUPA
RUSP
SPTO
LYFL
POND 3
AEGL
DILO
PRSE
LIBE
ASPL
PASP
POND 4
PHAM
ATPY
ONSE
RUHI
ELUM
CAFR, CHMA, VITS, SACA
ROMU
VIPA
POAC
SPSP

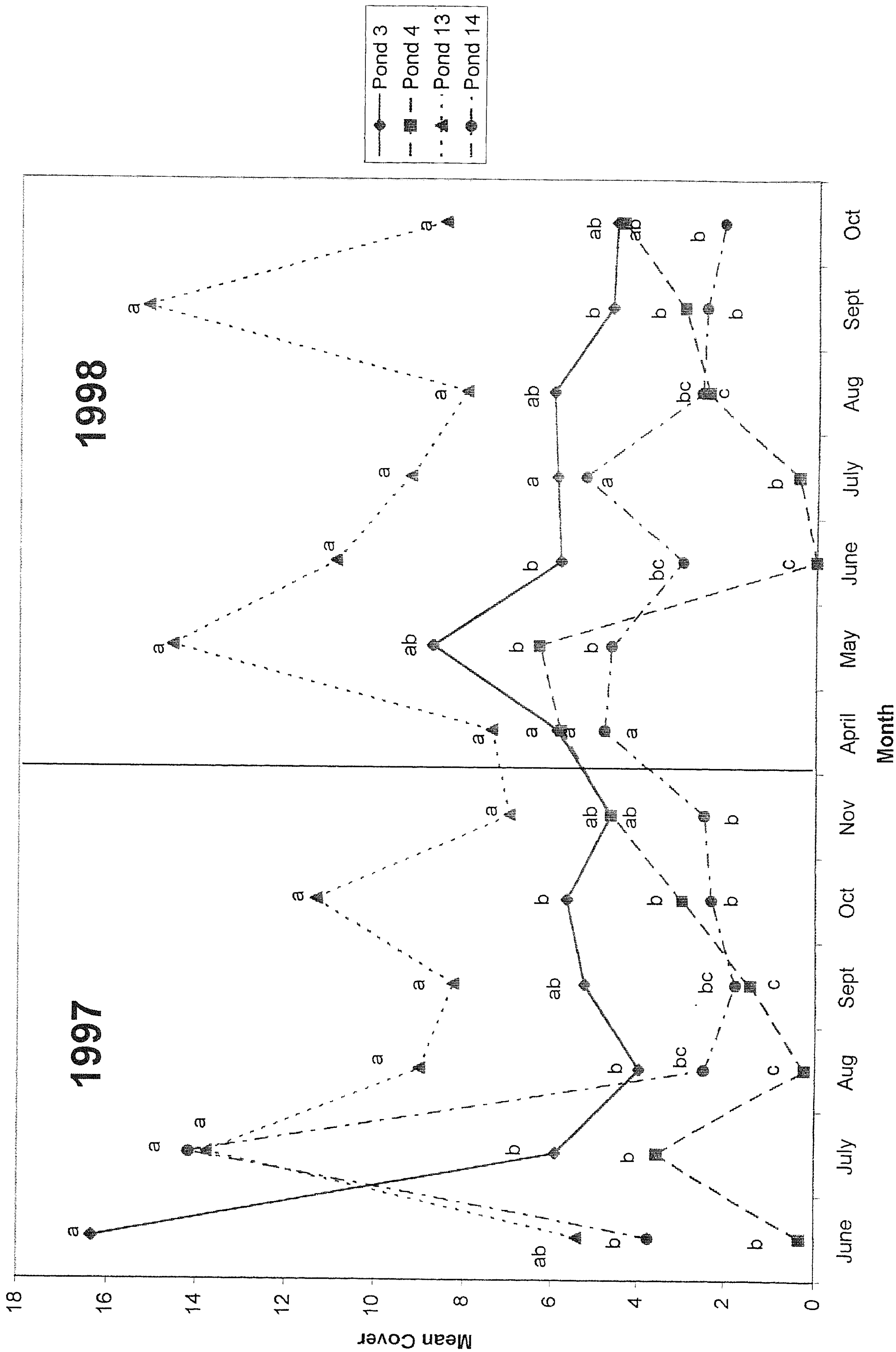
Pond 4 (Tables 16 and 17). *Lindera benzoin* and *V. papilionacea* had higher overall importance in 1998 than 1997 at Pond 4 (Tables 16 and 17). *Rubus hispidus* had higher importance for Pond 4 in 1997 (Table 16), contrary to axis ordination results, but ordination may be explained by a higher importance value at Pond 13 in 1998 than 1997. *Lycopodium flabelliforme* was found exclusively at Pond 3, with an importance value of 4.91 in 1997 and 4.17 in 1998 (Tables 16 and 17). As previously mentioned, *Lonicera japonica* (LOJA) was more closely associated with Pond 13 than with other ponds. *Quercus velutina* (QUVE), *Quercus alba* (QUAL), and *Juncus effusus* (JUEF) were of greater overall importance at Pond 14 than other ponds (Tables 16 and 17). *Quercus alba* and *J. effusus* were of higher importance at Pond 14 in 1998 than 1997, while *Q. velutina* had higher importance at Pond 14 during 1997 (Table 16). *Nyssa sylvatica* (NYSY) also was of greatest importance at Pond 14, while the overall average importance value was higher in 1998 than 1997 (Tables 17 and 16, respectively).

As with the tree and shrub communities, pond site ordinations for the herbaceous community were determined by species presence, with similarities and differences in importance values of species present at pond sites serving as determinants for ordination. Herbaceous species also may have been affected by site characteristics and conditions.

To provide some ideas of seasonal variation of important herbs at all four pond sites studied, one way analysis of variance (ANOVA) was run for *Lonicera japonica* (Figure 10), *Juncus effusus* (Figure 11), and *Smilax glauca* (Figure 12).

Lonicera japonica had the highest overall mean density at Pond 13 in both 1997 and 1998. Different ponds showed different peak times for greatest percent cover in both years. In 1997, Pond 3 showed greatest cover in June, Pond 4 in November, and Ponds

Figure 10. Monthly variability in *Lonicera japonica* over two consecutive growing seasons (1997 and 1998) at McClintic Wildlife Management Area, Mason County, West Virginia. Means with the same letters are not significantly different at the P<0.10 level.

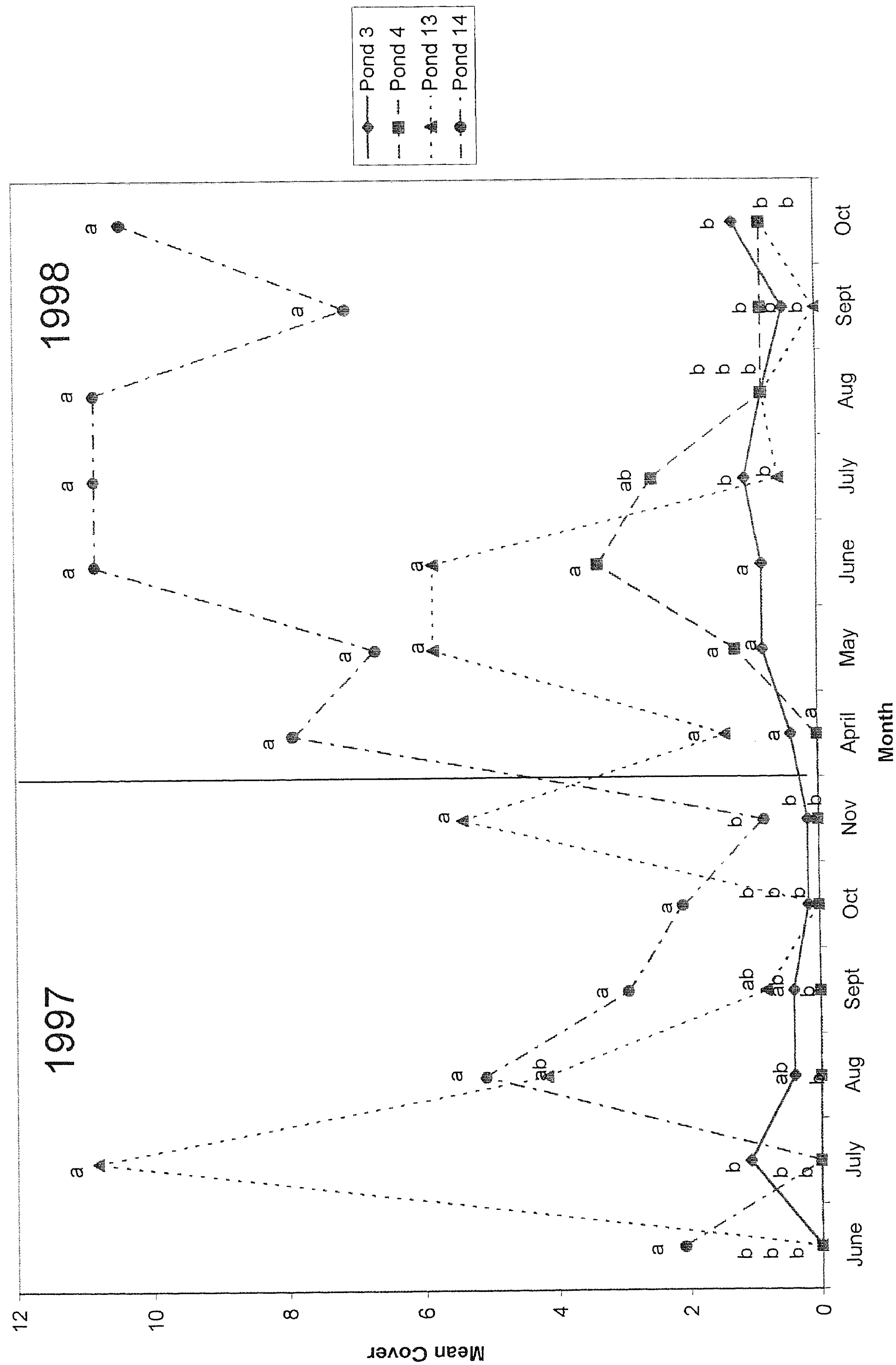

Pond 3
Pond 4
Pond 13
Pond 14
1997
1998
Mean Cover
Month
June
July
Aug
Sept
Oct
Nov
April
May
June
July
Aug
Sept
Oct
0
2
4
6
8
10
12
14
16
18

13 and 14 in July. The unusually high amount in November for Pond 4 may be from late-season mortality among other species, leaving *L. japonica* more area for cover. However, compared with other pond sites, *L. japonica* had the lowest cover at Pond 4. In 1998, high cover of *L. japonica* was recorded at Ponds 3 and 4 in May. Pond 14 showed highest cover in July, while Pond 13 had high covers in May and September. Overall, peak cover times for each year were July 1997 and May 1998, characteristic of published findings from Strausbaugh and Core (1977).

Juncus effusus had highest mean cover at Pond 13 in 1997 and was not observed on Pond 4. Peak covers were noted in July for Ponds 13 and 3 and August for Pond 14 (Figure 11). In 1998, peaks were June, July, and August on Pond 14, May and June for Pond 13, June for Pond 4, and October for Pond 3. According to Strausbaugh and Core (1977), the species peaks between June and August. Inconsistencies from September to October at Pond 14 may be explained by greater prevalence of the species resulting from decline of other species. Overall peak cover times for each year were July 1997 and June 1998, characteristic of findings by Strausbaugh and Core (1977).

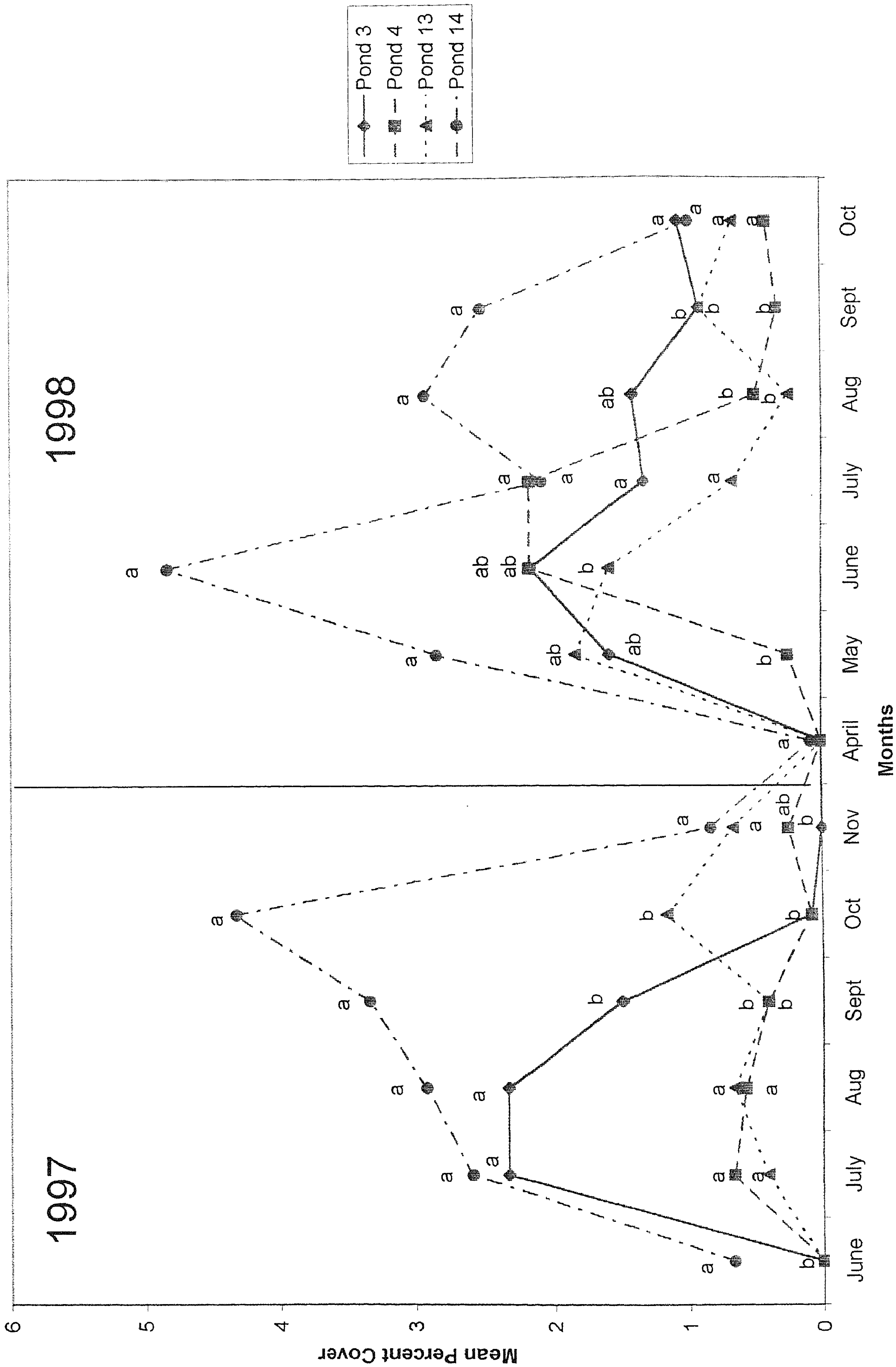
Smilax glauca also was found in different amounts at each pond site and had different peak times depending on location (Figure 12). The species, in 1997, had highest cover in October at Pond 14, July and August at Pond 3, July at Pond 4, and August at Pond 13. In 1998, the species peaked at Ponds 14, 4, and 3 in June, and Pond 13 in May. The species usually peaks in May and June, so 1998 values were more consistent with literature (Strausbaugh and Core 1977). Overall peak cover times for each year were August 1997 and June 1998, differing slightly from peak times published by Strausbaugh and Core (1977) as May and June.

Figure 11. Monthly variability in *Juncus effusus* over two consecutive growing seasons (1997 and 1998) at McClintic Wildlife Management Area, Mason County, West Virginia. Means with the same letters are not significantly different at the $P<0.10$ level.



Pond 3
Pond 4
Pond 13
Pond 14
1997
1998
Mean Cover
Month
June
July
Aug
Sept
Oct
Nov
April
May
0
2
4
6
8
10
12

Figure 12. Monthly variability in *Smilax glauca* over two consecutive growing seasons (1997 and 1998) at McClintic Wildlife Management Area, Mason County, West Virginia. Means with the same letters are not significantly different at the P<0.10 level.


Pond 3
Pond 4
Pond 13
Pond 14
1997
1998
Mean Percent Cover
0
1
2
3
4
5
6
June
July
Aug
Sept
Oct
Nov
April
May
June
July
Aug
Sept
Oct
Months

Aquatic Species Analysis

In West Virginia, aquatic species are common in farm and other ponds, though generally no natural ponds exist (Core 1966). Species such as *Ceratophyllum demersum* and *Ludwigia palustris* may become established in open water of ponds, up to a depth of 5 feet (Core 1966). Along shores, rooted herbs are often found, including *Polygonum* sp., *Bidens* sp., and sedges (Core 1966). Water regime, which is often itself influenced by soils, vegetation, snow accumulation, groundwater flow, and weather (Shay et al. 1999, Kantrud et al. 1989), can play an important role in freshwater wetland ecology (Shay et al. 1999, Harris and Marshall 1963, Millar 1973, Spence 1982, Squires and van der Valk 1992). As a result, aquatic vegetation should be analyzed in any wetland vegetation study. Because of their dependence on physical and chemical characteristics of water, aquatic plants can also be used as indicators of river water quality (Onaindia et al. 1996, Peñuelas 1984), making them a necessary part of any wetland analysis.

Overall mean cover for aquatic species in all sampled ponds during 1997 and 1998 varied among ponds (Table 18). Ponds 4 and 13 had increases in overall mean cover, while Ponds 3 and 14 had decreases. Pond 14 had the most change in mean cover of aquatic species from 1997 to 1998. Changes (given in percents) were 19.49 for Pond 3, 2.58 for Pond 4, 16.80 for Pond 13, and 38.40 for Pond 14.

One-way analysis of variance on mean aquatic cover for pond sites during 1997 and 1998 showed that, for both years, all four means were significantly different at the

Table 18. Mean cover (percent) for aquatic species on four ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. A dash indicates the species was not present on a particular pond.

1997

Species	Pond 3	Pond 4	Pond 13	Pond 14
Alnus serrulata	-	-	0.83	2.50
Bidens sp.	-	0.04	-	-
Ceratophyllum demersum	40.62	4.51	0.39	36.38
Cephalanthus occidentalis	-	1.78	5.50	15.42
Cyperus sp.	-	-	6.81	-
Eupatorium sp.	-	-	0.43	-
Juncus effusus	-	-	-	0.14
Lemna minor	74.31	0.45	-	0.01
Leersia oryzoides	-	0.08	-	-
Ludwigia palustris	-	0.11	3.65	4.96
Polygonum hydropiperoides	-	0.62	4.24	0.75
Totals	114.93	7.60	21.84	60.15

1998

Species	Pond 3	Pond 4	Pond 13	Pond 14
Alnus serrulata	-	-	1.73	0.14
Carex sp.	-	-	-	0.04
Ceratophyllum demersum	9.70	4.39	4.62	5.24
Cephalanthus occidentalis	-	1.20	0.51	1.04
Eupatorium perfoliatum	-	-	0.51	-
Eupatorium serotinum	-	-	0.93	-
Hypericum virginicum	-	1.31	-	-
Lemna minor	85.10	1.83	-	-
Leersia oryzoides	-	-	0.24	-
Ludwigia palustris	-	-	6.46	15.30
Onoclea sensibilis	-	0.01	-	-
Osmunda cinnamomea	-	0.02	-	-
Panicum sp.	-	0.06	0.48	-
Polystichum acrostichoides	-	1.32	0.10	-
Polygonum hydropiperoides	0.30	0.02	21.88	-
Polygonum persicaria	-	-	0.37	-
Polygonum sagittatum	-	-	0.54	-
Spiraea tomentosa	0.36	-	-	-
Utrichularia gibba	-	-	0.27	-
Totals	95.44	10.18	38.64	21.75

Table 19. Mean cover of aquatic plants of four sampled ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. Values given are means ± 1 S.E. All four means were significantly different at the P<0.10 level.

1997 Pond	Mean Cover (%)
3	114.93 ± 6.65^{a}
4	7.60 ± 1.10^{b}
13	21.84 ± 4.09^{c}
14	60.15 ± 5.20^{d}

1998 Pond	Mean Cover (%)
3	95.44 ± 2.77^{a}
4	10.18 ± 1.44^{b}
13	38.64 ± 3.31^{c}
14	21.75 ± 2.45^{d}

P<0.10 level (Table 19). Since species present, and percent cover, varied greatly between pond sites, it is not surprising to have significantly different means.

For both years, the top five aquatic species were *Ceratophyllum demersum*, *Lemna minor*, *Ludwigia palustris*, *Cephalanthus occidentalis*, and *Polygonum hydropiperoides* (Table 20). These five species were present with much greater importance, over all ponds, than any other species. Because of significant changes in aquatic pond vegetation between years, it is difficult to definitively say that any ponds had particularly dominant species, except that in Pond 3, *C. demersum* and *Lemna minor* were dominant for both years (Table 21).

DCA pond site ordinations for aquatic vegetation in 1997 and 1998 showed that ponds did not separate as much in ordination space for aquatic species as for other strata, but tended to remain more on a continuum than trees, shrubs, and herbs (Figure 13). Such a phenomenon may be explained by large dissimilarities in types and amounts of species present in ponds in each year. In effect, ponds may not have shared enough common species for DCA ordinations to be far from one another. Ponds 4, 13, and 14 had a larger amount of variation than Pond 3, with Pond 13 showing overall increases. Ponds 3 and 13 were least associated with respect to aquatic plants.

Plotted with pond DCA ordinations are three dominant aquatic species: *Ceratophyllum demersum* (CEDE), *Lemna minor* (LEMI), and *Ludwigia palustris* (LUPA) (Figure 13). Considering both years, *Ceratophyllum demersum* was of greatest importance in Pond 4, where it had higher importance values in 1997 than 1998 (Table 21). The species was more important in Pond 3 in 1997 than in 1998, more important in Pond 14 in 1997 than 1998, and more important in Pond 13 in 1998. *Lemna minor*

Table 20. Overall importance values (average relative cover) for aquatic species in four ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998.

Species	Importance Value
Ceratophyllum demersum	30.80
Lemna minor	22.21
Ludwigia palustris	14.19
Cephalanthus occidentalis	11.51
Polygonum hydropiperoides	10.76
Cyperus sp.	3.89
Polystichum acrostichoides	1.65
Alnus serrulata	1.64
Hypericum virginicum	1.61
Eupatorium serotinum	0.30
Eupatorium sp.	0.25
Panicum sp.	0.23
Leersia oryzoides	0.22
Polygonum sagittatum	0.18
Eupatorium perfoliatum	0.17
Polygonum persicaria	0.12
Utrichularia gibba	0.09
Bidens sp.	0.07
Spiraea tomentosa	0.05
Juncus effusus	0.03
Osmunda cinnamomea	0.03
Carex sp.	0.02
Onoclea sensibilis	0.01
Total	100.00

Table 21. Relative cover (percent) and importance values for aquatic species at four ponds at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998. A dash indicates the species was not present on a particular pond.

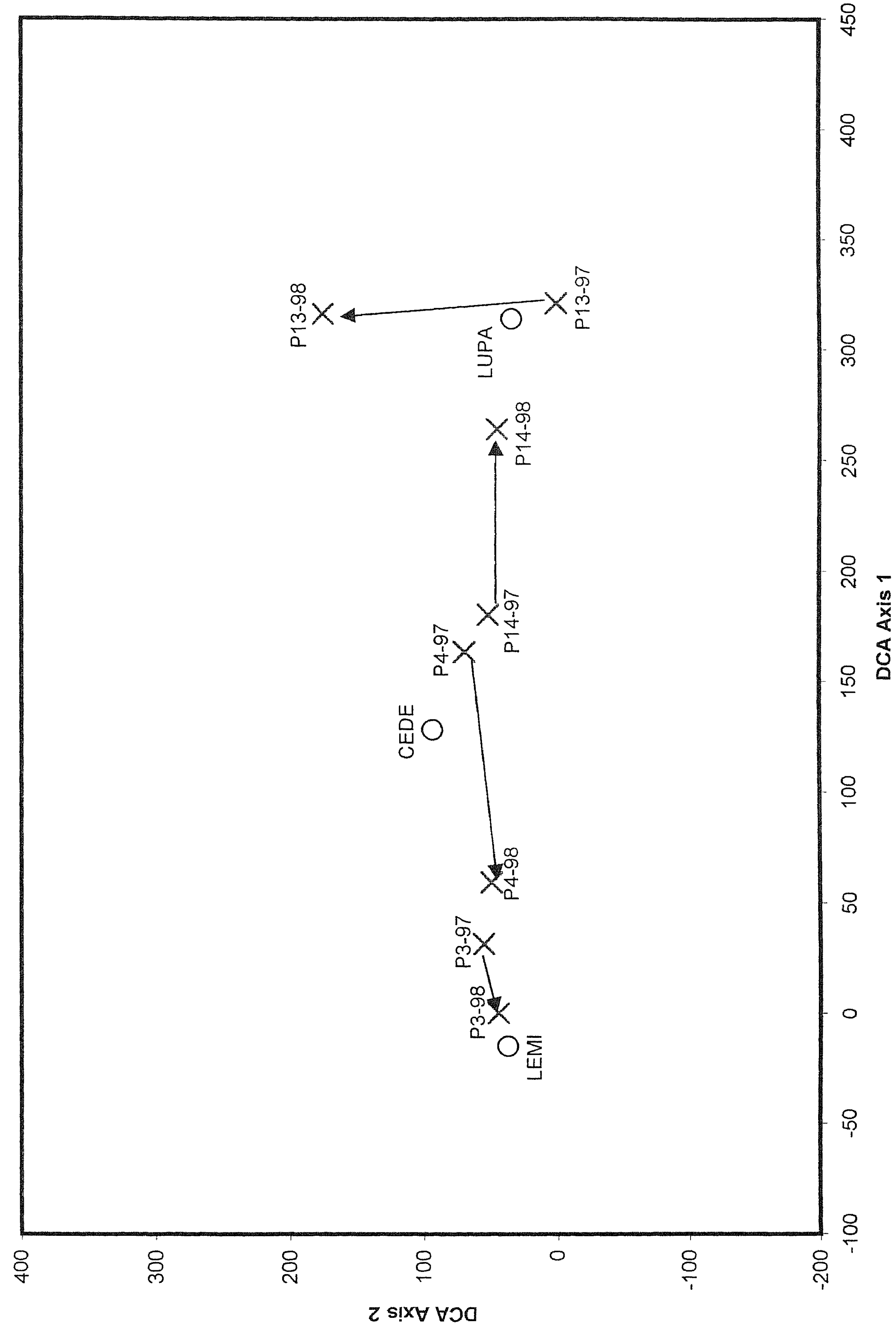
1997

Species	Overall	Pond 3	Pond 4	Pond 13	Pond 14
Ceratophyllum demersum	39.25	35.35	59.39	1.78	60.47
Cephalanthus occidentalis	18.55	-	23.40	25.18	25.63
Lemna minor	17.63	64.65	5.86	-	0.02
Cyperus sp.	7.79	-	-	31.15	-
Polygonum hydropiperoides	7.22	-	8.25	19.40	1.24
Alnus serrulata	1.99	-	-	3.81	4.16
Ludwigia palustris	6.61	-	1.47	16.72	8.24
Eupatorium sp.	0.49	-	-	1.97	-
Leersia oryzoides	0.28	-	1.10	-	-
Bidens sp.	0.14	-	0.55	-	-
Juncus effusus	0.06	-	-	-	0.23
Totals	100.00	100.00	100.00	100.00	100.00

1998

Species	Overall	Pond 3	Pond 4	Pond 13	Pond 14
Lemna minor	26.79	89.16	18.01	-	-
Ceratophyllum demersum	22.34	10.15	43.16	11.96	24.08
Ludwigia palustris	21.77	-	-	16.73	70.33
Polygonum hydropiperoides	14.30	0.31	0.24	56.64	-
Cephalanthus occidentalis	4.48	-	11.81	1.32	4.77
Polystichum acrostichoides	3.31	-	12.98	0.25	-
Hypericum virginicum	3.22	-	12.87	-	-
Alnus serrulata	1.28	-	-	4.47	0.66
Eupatorium serotinum	0.60	-	-	2.40	-
Panicum sp.	0.46	-	0.60	1.23	-
Polygonum sagittatum	0.35	-	-	1.39	-
Eupatorium perfoliatum	0.33	-	-	1.33	-
Polygonum persicaria	0.24	-	-	0.95	-
Utrichularia gibba	0.18	-	-	0.71	-
Leersia oryzoides	0.16	-	-	0.62	-
Spiraea tomentosa	0.09	0.37	-	-	-
Osmunda cinnamomea	0.06	-	0.24	-	-
Carex sp.	0.04	-	-	-	0.16
Onoclea sensibilis	0.03	-	0.11	-	-
Totals	100.00	100.00	100.00	100.00	100.00

Figure 13. Detrended correspondence analysis (DCA) of sampled aquatic communities in 1997 and 1998 at McClintic Wildlife Management Area, Mason County, West Virginia, by pond location, with dominant species. Code names for dominant species: LEMI = *Lemna minor*; CEDE = *Ceratophyllum demersum*; LUPA = *Ludwigia palustris*.

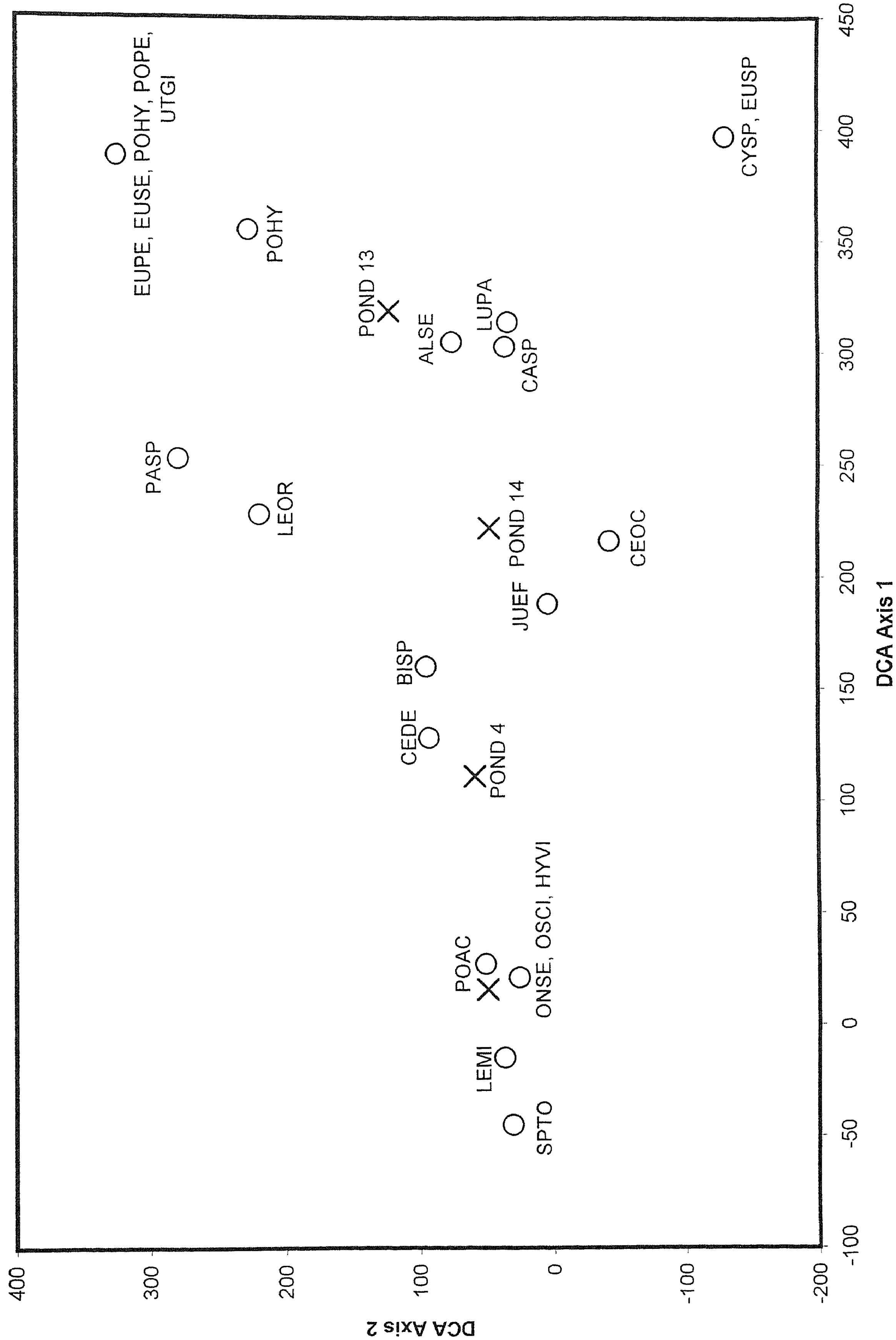

DCA Axis 1
DCA Axis 2
P13-98
P13-97
LUPA
P14-98
P14-97
P4-97
CEDE
P4-98
P3-97
P3-98
LEMI
-100
-50
0
50
100
150
200
250
300
350
400
450
-200
-100
0
100
200
300
400

was not present in Pond 13 during either sampling year, was present in smaller amounts in Pond 4 (higher in 1998), and was present in Pond 14 in 1997 but not 1998. The species was of highest importance in Pond 3, where it had a higher importance value in 1998 than in 1997 (Table 21). *Lemna minor* was the dominant aquatic species in Pond 3 for both years, with relative averages of 64.65 in 1997 and 89.16 in 1998 (Table 21). *Ludwigia palustris*, not present in Pond 3 during either year, was of greatest importance in Pond 14 in 1998 (Table 21). The species was present in Pond 4 in 1997 but not 1998, and was present in Pond 13 both years.

DCA of all aquatic vegetation illustrated variation in species presence among ponds (Figure 14). *Spiraea tomentosa* (SPTO) was only found in Pond 3 during 1998. Species such as *Onoclea sensibilis*, *Osmunda cinnamomea*, and *Hypericum virginicum* were only found in Pond 4 during 1998; *Polystichum acrostichoides* was only found in Ponds 4 and 13 during 1998 (Table 21). These species were found during a period of low pond level and were gone when pond water levels again increased. Species with ordinations in the center of the graph, such as *Ceratophyllum demersum* and *Cephalanthus occidentalis*, were found in most ponds during both years. Generally, species had ordinations closest to the ponds in which they were of greatest importance and the year in which they had highest importance values. Species such as *Eupatorium perfoliatum*, *Eupatorium serotinum*, *Polygonum persicaria*, and *Utricularia gibba* were found only in Pond 13 in 1998, while *Cyperus* sp. and *Eupatorium* sp. were found in Pond 13 only in 1997 (Table 21).

As with other plant strata, pond ordinations on the DCA graphs are most likely affected by presence of aquatic species. Time may also have been a factor, yet

Figure 14. Detrended correspondence analysis (DCA) of aquatic species at McClintic Wildlife Management Area, Mason County, West Virginia, with ordinations of all species, together with average pond site ordinations for 1997 and 1998. See Table 1 for species code names.

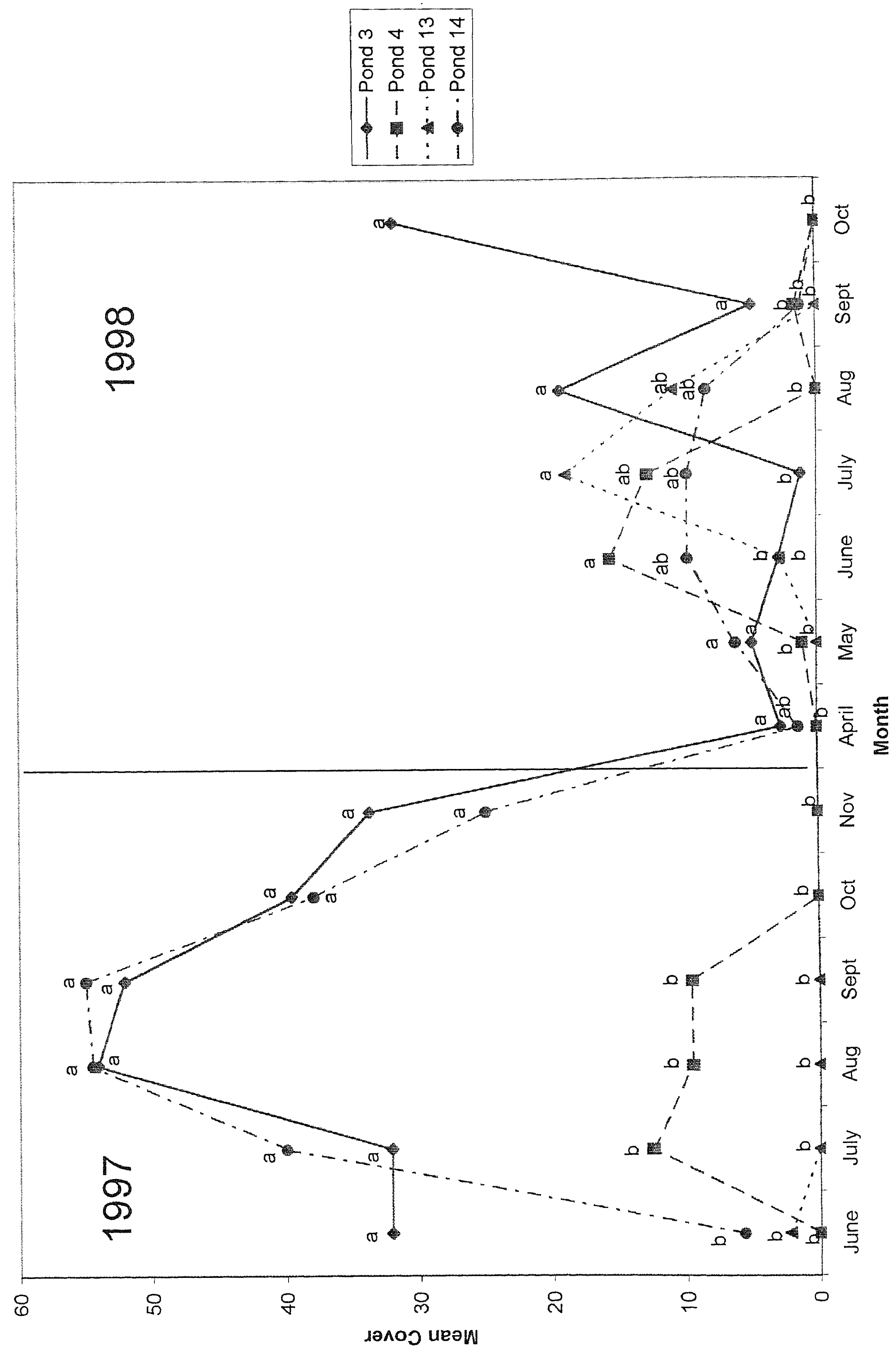


DCA Axis 1
DCA Axis 2
-100
-50
0
50
100
150
200
250
300
350
400
450
-200
-100
0
100
200
300
400
EUPE, EUSE, POHY, POPE, UTGI
POHY
PASP
LEOR
POND 13
ALSE
LUPA
CASP
POND 14
JUEF
CEOC
BISP
CEDE
POND 4
POAC
ONSE, OSCI, HYVI
LEMI
SPTO
CYSP, EUSP

seemed only to have an effect at Pond 13, since this site was the only one to have higher axes values in 1998. Higher axes values for this Pond may be substantiated by noting that the species of highest importance in Pond 13 in 1998, *Polygonum hydropiperoides*, was of significantly less importance in 1997 (Table 21). Furthermore, *P. hydropiperoides* ordinated closest to 1998 axes values for Pond 13 (Figures 13 and 14), showing a close relationship between the pond site and species ordinations. Aquatic species, as with trees, shrubs, and herbs, may be affected by site characteristics, especially if water quality, depth, or amount of nutrients differed from one pond location to another. However, aquatic species showed more extreme changes in overall importance among ponds and years than other growth habits. Some explanation may be provided by differences in water levels or water quality among ponds. Most aquatic plants require fine-textured substratum, shallow environments, and slow current for optimal survival (Onaindia et al. 1996). While sampling was consistent from month to month at each pond, differences in water levels may have contributed to changes in types and abundance of species present. For example, *Ceratophyllum demersum* is a submerged aquatic species (Strausbaugh and Core 1977), so receding water levels may lead to decline of a population, should the species not be able to float out with receding margins. Additionally, it is possible that wind activity might have affected water movement and thus abundance along shorelines of non-rooted aquatic vegetation. The same is true of other species; emergents and species requiring damp environments, but not able to survive in standing water, would be directly affected by different water levels.

Seasonal patterns of *Ceratophyllum demersum* showed that in 1997, the species was much more abundant, with greatest cover in Ponds 3 and 14 (Figure 15). Peak times

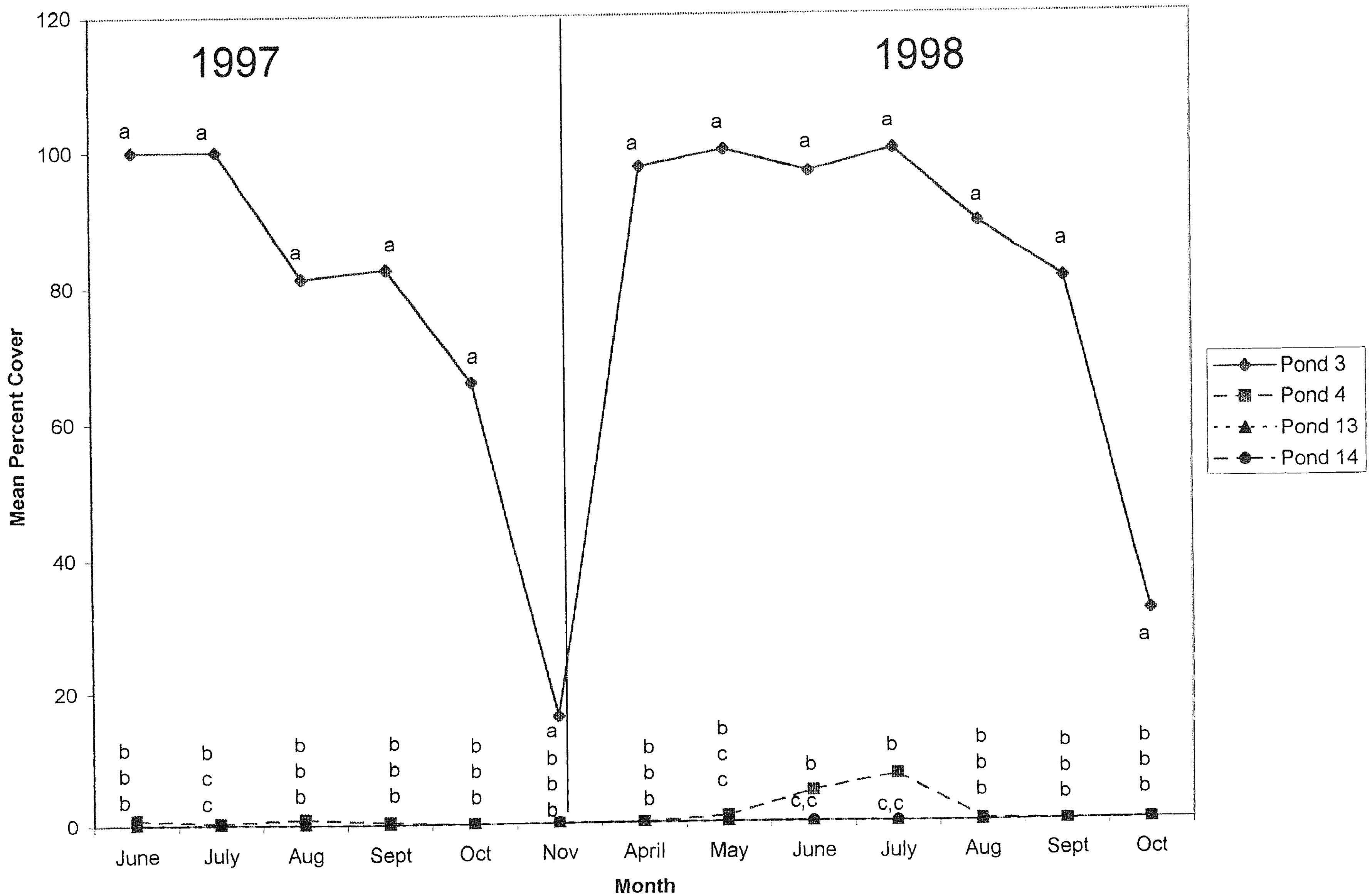
Figure 15. Monthly variability in mean cover of *Ceratophyllum demersum* over two consecutive growing seasons (1997 and 1998) at McClintic Wildlife Management Area, Mason County, West Virginia. Means with the same letters are not significantly different at the P<0.10 level.


1997
1998
Pond 3
Pond 4
Pond 13
Pond 14
Mean Cover
Month
0
10
20
30
40
50
60
June
July
Aug
Sept
Oct
Nov
April
May
June
July
Aug
Sept
Oct

for the species were August for Pond 3, September for Pond 14, July for Pond 4, and June for Pond 13. In 1998, mean cover of the species was greatly reduced in Ponds 3 and 14, was very similar in Pond 4, and increased in Pond 13 (Table 21). In 1998, greatest cover was in July in Pond 13, June in Pond 4, October in Pond 3, and June in Pond 14. The species tends to be at its peak in June and July (Strausbaugh and Core 1977), but highest relative cover values in Pond 3 may be explained by decreasing amounts of *Lemna minor* in Pond 3 (Table 21).

As another example, seasonal patterns of *Lemna minor* are illustrated (Figure 16). *Lemna minor* is characteristic of sites where average depth of water is high and nutrient supply is ample, and the species is usually an indicator of high depths rich in nutrients (Onaindia et al. 1996). For both 1997 and 1998, the species was found in greatest abundance in Pond 3. Peak times were June and July in 1997 and May and July in 1998. The species was not found in Pond 13 either year, and only in very small amounts in Ponds 4 and 14 (Tables 18 and 21). Overall peak times for all ponds were June 1997 and July 1998, consistent with literature (Strausbaugh and Core 1977). *Lemna minor* is a floating species found on tops of ponds, while *C. demersum* is a submerged species (Strausbaugh and Core 1977), in effect creating two "layers" of aquatic vegetation. This phenomenon explains why mean cover for Pond 3 in 1997 was over 100 percent (Table 18). Additionally, when comparing *C. demersum* with *L. minor* (Figures 15 and 16), mean covers of *C. demersum* increased in October 1998 when levels of *L. minor* were decreasing. This may be because *C. demersum* was able to receive more light and have more ideal conditions for growth and survival.

Figure 16. Monthly variability in mean cover of *Lemna minor* over two consecutive growing seasons (1997 and 1998) at McClintic Wildlife Management Area, Mason County, West Virginia. Means with the same letter are not significantly different at the P<0.10 level.


1997
1998
Mean Percent Cover
Month
120
100
80
60
40
20
0
June
July
Aug
Sept
Oct
Nov
April
May
June
July
Aug
Sept
Oct
Pond 3
Pond 4
Pond 13
Pond 14

Chapter IV. Overall Analysis

Based on the history of MWMA, and since various strata of plant species, from aquatic and submerged species to upland forest species, are present, the area provides notable conditions that may not typically be encountered. Wetland status of species in each growth stratum as indicated by Williams et. al. (1999) and Reed (1988) is provided (Tables 22-25). Wetland status was not available for some species, either because it has not been determined or is unattainable because only genus (and not species) was determined for a given plant. Wetland species are classified as follows (Williams et al. 1999, Reed 1988): OBL-obligate wetland-species almost always occurring (99%) in wetlands; FACW-facultative wetland-usually occurring (67 to 99%) in wetlands; FAC-facultative-occurring in both wetlands and uplands (33 to 67%); FACU-facultative upland-occasionally occurring (1 to 33%) in wetlands. In all growth habits, a majority (>60%) of species had determined wetland status: 67% each for shrubs and herbs, 80% for trees, and 91% for aquatics. It would seem logical that almost 100% of aquatic species would have determined wetland status; however, two species (*Eupatorium* sp. and *Panicum* sp.) had undetermined status because they were identifiable only to genus level.

It is difficult to assess the extent that establishment of West Virginia Ordnance Works had on plant species composition at MWMA, because no previous records are available prior to site disruption, and inferences cannot easily be made. Previous West Virginia studies have suggested that radiation and thermal conditions, rather than

Table 22. Tree species encountered at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998, with wetland status, if applicable (Wetland status from Reed 1988). Dashes indicate either the wetland status is undetermined or non-existent. Codes for wetland status: FAC = facultative; FACU = facultative upland.

Species	Wetland Status
Acer rubrum	FAC
Asimina triloba	FACU
Cornus florida	FACU
Elaeagnus umbellata	---
Fagus grandifolia	FACU
Nyssa sylvatica	FAC
Quercus alba	FACU
Quercus imbricaria	FAC
Quercus palustris	---
Sassafras albidum	FACU

Table 23. Shrub species encountered at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, with wetland status, if applicable (Wetland status from Reed 1988). Dashes indicate either the wetland status is undetermined or non-existent. Codes for wetland status: FAC = facultative; FACU = facultative upland; FACW = facultative wetland.

Species	Wetland Status
Acer rubrum	FAC
Asimina triloba	FACU
Carya ovata	FACU
Corylus americana	FACU
Cornus florida	FACU
Elaeagnus umbellata	---
Eupatorium serotinum	FAC
Eupatorium sp.	---
Ilex montana	---
Lindera benzoin	FACW
Lonicera japonica	FAC
Nyssa sylvatica	FAC
Osmunda cinnamomea	FACW
Quercus alba	FACU
Quercus imbricaria	FAC
Quercus velutina	FACU
Rhus vernix	---
Rosa multiflora	FACU
Robinia pseudo-acacia	FACU
Rubus sp.	---
Sassafras albidum	FACU
Smilax glauca	FACU
Solidago sp.	---
Viburnum recognitum	FACW
Vitis sp.	---

Table 24. Herbaceous species encountered at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998, with wetland status, if applicable (Wetland status from Reed 1988). Because of the large number of species, codes are used rather than complete names (See Table 1 for species names). Dashes indicate either the wetland status is undetermined or non-existent.

Code	Wetland Status	Code	Wetland Status	Code	Wetland Status
ACRU	FAC	LIBE	FACW	QUIM	FAC
AEGL	FACU	LOJA	FAC	QUPA	---
ALSE	FACW	LUPA	OBL	QUVE	---
ASTR	FACU	LYAM	OBL	RHRA	---
ASPL	---	LYFL	FACU	ROMU	FACU
ATPY	FAC	LYVI	OBL	ROPS	FACU
CAFR	OBL	MOAL	---	RUHI	FACW
CASP	---	NYSY	FAC	RUSP	---
CAOV	FACU	ONSE	---	SAAL	FACU
CHMA	---	PAQU	FACU	SACA	FACW
COAM	FACU	PASP	---	SCSP	OBL
COFL	FACU	PHAM	FACU	SEFA	---
CUOR	---	PLOC	FACW	SMGL	FACU
DASP	---	POAC	OBL	SOSP	---
DILO	---	POHY	OBL	SPSP	---
ELUM	---	POSA	OBL	SPTO	FACW
EUSE	FAC	POSI	FACU	VIPR	FACU
JUEF	FACW	PRSE	FACU	VIPA	---
LEMI	OBL	QUAL	FACU	VISP	---

Table 25. Aquatic species encountered at four pond sites at McClintic Wildlife Management Area, Mason County, West Virginia, during 1997 and 1998, with wetland status, if applicable (Wetland status from Reed 1988). Dashes indicate either the wetland status is undetermined or non-existent. Codes for wetland status: FACW = facultative wetland; OBL = obligate wetland; FAC = facultative wetland; FACU = facultative upland.

Code	Wetland Status
Alnus serrulata	FACW
Bidens sp.	OBL
Carex sp.	OBL
Ceratophyllum demersum	OBL
Cephalanthus occidentalis	OBL
Cyperus sp.	OBL
Eupatorium perfoliatum	FACW
Eupatorium serotinum	FAC
Eupatorium sp.	---
Hypericum virginicum	OBL
Juncus effusus	FACW
Lemna minor	OBL
Leersia oryzoides	OBL
Ludwigia palustris	OBL
Onoclea sensibilis	FACW
Osmunda cinnamomea	FACW
Panicum sp.	---
Polystichum acrostichoides	FACU
Polygonum hydropiperoides	OBL
Polygonum persicaria	FACW
Polygonum sagittatum	OBL
Spiraea tomentosa	FACW
Utrichularia gibba	OBL

differences in soil chemical or physical properties, may better explain tree growth (Leopold and Parker 1985, Lee and Sypolt 1974). It is known that when disturbance does not occur, distributions of herbs and shrubs undergo little year-to-year change, but removal of the overstory can cause changes in community structure and species importance (Hughes and Fahey 1991, Hughes 1987, Bicknell 1979).

In some forests, distribution of herbs and shrubs may remain unchanged because many species are able to establish themselves on sites prior to disturbance, and under many conditions, spatial patterns may remain the same for many years (Hughes and Fahey 1991). More light reaching the understory, as a result of tree death or tree cutting, can result in increased abundance of woody species, with frequencies related to size of canopy opening (Reader and Bricker 1992, Sander and Clark 1971, Smith 1981, Runkle 1982, Canham and Marks 1985, Phillips and Shure 1990). Additionally, species that have occupied specific sites at one time are likely to remain on those locations for extended periods of time. Species may also enable other plants to establish themselves, causing greater species diversity and richness in the forest (Hughes and Fahey 1991, Connell and Slatyer 1977, Horsley and Marquis 1983). Therefore, it is possible that species presently found at McClintic were present prior to establishment of West Virginia Ordnance Works, and presence of some species may have encouraged other species to establish.

Chapter V. Conclusions

Despite the establishment of West Virginia Ordnance Works as McClintic Wildlife Management Area, vegetation studies of the area were lacking, and this project aimed to provide at least some description of such plant life. Specific objectives were: to characterize plant communities in and around selected holding ponds at MWMA; to analyze similarities and differences in vegetation between ponds and sampling years; and to provide baseline data of plant communities for use in future research.

Results from four sampled plant strata (trees, shrubs, herbaceous, and aquatic) indicated that, in general, ponds shared many similar species, though in all growth forms, certain species were present at some ponds and absent from others. Yearly changes in important species at pond sites occurred between all plant strata, with extent of change based on the plant stratum being considered and the pond site location. DCA analysis showed that for trees, Ponds 3, 4, and 14 showed more noticeable change than Pond 13, which was nearly identical from 1997 to 1998. Shrub species showed the smallest amount of variability between years, with pond site ordination points for 1997 and 1998 more closely related than other growth strata. Herb species showed greater changes at Ponds 13 and 14 than at Ponds 3 and 4. More significant yearly pond changes were seen for aquatics, most likely the result of disjunct distributions of species among ponds from year to year, and from species high in abundance in some ponds being present in smaller amounts or absent from other ponds.

For individual strata, changes in basal area, density, and cover were observed. For trees, Ponds 3 and 14 had increases in total basal area and density between years, Pond 4 had decreases in total basal area and density, and Pond 13 remained nearly the same. Increases in density of shrubs at all pond sites were observed from 1997 to 1998. Herbaceous mean cover showed increases at all ponds between 1997 and 1998, with some ponds having more increases than others. Ponds 4 and 13 had greater increases in mean cover than Ponds 3 and 14. Mean cover of aquatic species increased for Ponds 4 and 13 and decreased for Ponds 3 and 14 from 1997 to 1998.

In future studies of MWMA, more research needs to be performed to document additional vegetation of the area, and future ecological studies should examine environmental factors, such as aspect, elevation, and soil conditions to see if such phenomena play roles in occurrence and distribution of species in and around ponds. Aulick (1993) stated that a single factor should not be considered as being the sole determinant in vegetation analysis; the same should be applied to the current study. Future projects should re-evaluate the areas sampled for this project and combine this study, in order to make more definitive conclusions about plant life present and changes occurring between pond sites.

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